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INVESTIGATION OF TRANSPORTABLE SEARCH RADAR AND S I F EQUIPMENT (U)

FINAL REPORT

4 APRIL 1962 - 30 SEPTEMBER 1962

Prepared for

ELECTRONICS REASEARCH DIRECTORATE
AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
OFFICE OF AEROSPACE RESEARCH
UNITED STATES AIR FORCE
BEDFORD, MASSACHUSETTS

RCA

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INVESTIGATION OF TRANSPORTABLE SEARCH RADAR AND SIF EQUIPMENT (U)

RADIO CORPORATION OF AMERICA
BURLINGTON, MASSACHUSETTS

AF19(604)-8020
Phase IV

FINAL REPORT

Project 2124
Task 46227

4 April 1962 - 30 September 1962

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Prepared For

ELECTRONICS RESEARCH DIRECTORATE
AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
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FOREWORD

Work on this project was performed at Fort Dawes, Massachusetts, under Contract No. AF19(604)-8020, issued by the Electronics Research Directorate, Air Force Cambridge Research Laboratories, Office of Aerospace Research, United States Air Force, Bedford, Massachusetts to Radio Corporation of America, Defense Electronic Products, Camden, New Jersey. The contractor personnel team was responsible to the Control Sciences Laboratory, which was designated prime contractor by the Air Force.

Information contained in this report is based on data given to the contractor personnel team by responsible representatives of manufacturers of the respective equipments and military personnel.

The Receiver Group discussion is bound under a separate cover as a Confidential supplement to this report.

ABSTRACT

The purpose of the project was to investigate transportable search radar and SIF equipments for application to the purposes of the Mobile ATC/ Communication Facility -- more commonly known as Augmented Four Wheels.

A thorough survey of the field of potentially applicable search radar and SIF equipments was undertaken. Available equipments were evaluated against a specific performance criterion, and five equipment systems were recommended as applicable to the Augmented Four Wheels program. Each of the five search radar systems was critically evaluated against Air Traffic Control criteria for the Quick Reaction Posture requirement of the Air Force.

Remote control requirements for the search radar and other subsystems, within the Augmented Four Wheels System complex, were thoroughly investigated. Microwave link equipments were evaluated, and specific performance characteristics were defined for use in the Augmented Four Wheels System.

Space and housing requirements for the search radar subsystem were critically studied, and definitive shelter specifications were prescribed. A Report was submitted to AFCRL under Contract AF19(604)-8020. Certain sections of the above mentioned Report are reprinted in the following Report to provide continuity.

After the decision was made by AFCRL, Control Sciences Laboratory, to accept a certain radar system, engineering studies were provided by the RCA team to modify the radar system if it were necessary;

supply detail drawings concerning the component layout inside and outside the shelter; consider the interface problems between the search radar system and the microwave remoting system; supply recommendations to the Control Science Laboratory on the entire AN/TPS-35 Subsystem which includes UHF communications equipment, interfacility, communications, power generators, air conditioner unit, shelter, microwave equipment, and the use of the anti-jam features of the radar system.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

SECTION 1

INTRODUCTION

The Mobile ATC/Comm Facility, more commonly known as the Augmented Four Wheels System, is a mobile/transportable Air Traffic Control system which was conceived as a means of controlling air traffic in and near airfields that do not have fixed ground equipment available. It was designed for transportable tactical applications.

An investigation was made of the applicability of certain transportable search radar and SIF equipments to the requirements of the Augmented Four Wheels System. This section discusses availablity selection, and modification of search radar equipments.

1.1 SURVEY OF SEARCH RADAR EQUIPMENTS

Table 1-1 is a complete list of ground and airborne radar systems designed as search radars supplying range information and aircraft position information.

As the table indicates, many of the radar systems could not apply to the requirements of a lightweight, air transportable, high-performance radar system.

1.2 SEARCH RADAR EQUIPMENT

Table 1-2 lists the search radar systems that meet, in most cases, the requirements for the AN/TPS-35 Radar System. The high performance required for air traffic control, plus the limit on weight and size of the equipment made it necessary to supply a list of five available radar equipments. The characteristics of these five systems are shown in Table 1-2.

Table 1-1. Survey of search radar equipment

Nomenclature	Manufacturer	Radar Type	Limitations	Comments
AN/APS-95	Hazeltine Corp	Airborne Set	No MTI: Wrong Antenna	Not Applicable
ARSR-1	Texas Instruments		Size and Wt	Too Large
ARSR-1A	Texas Instruments		Size and Wt	Too Large and Heavy
AN/ASR-2	Bendix Aviation Corp		Size and Wt	Too Large and Heavy
AN/ASR-3	Bendix Aviation Corp		Size and Wt	Too Large and Heavy
AN/ASR-4	Texas Instruments	Search	Requires Repackaging	Potentially Applicable
AN/ASR-MPN-11	Gilfillan Bros. Inc.	Search	Requires Repackaging	Potentially Applicable
AN/CPN-18	Bendix Aviation Corp		Set-Up Time; Wt	Too Large; Obsolete
AN/CPS-4			Size and Wt	Too Large
AN/CPS-6B	General Electric Co.		Size and Wt	Too Large
AN/CPS-9	Raytheon Company	Storm Detecting	X Band	Wrong Band; Wrong Type
AN/CPS-18	Bendix Aviation Corp			Obsolete
AN/FPN-16	Gilfillan Bros. Inc.	Approach Radar	X Band	Wrong Band; Wrong Type
AN/FPN-28	Bendix Aviation Corp	GCA System	Fixed Station	Wrong Type
AN/FPN-33		Navigation System		Wrong Type
AN/FPN-34	Bendix Aviation Corp	Ground Search	Weight	Not Transportable
AN/FPS-3	Bendix Aviation Corp	Search	Size and Wt	Too Heavy
AN/FPS-4	RCA	Height Finder		Wrong Type
AN/FPS-6	General Electric Co.	Height Finder		Wrong Type
AN/FPS-7	General Electric Co.	Height Finder		Wrong Type
AN/FPS-8	General Electric Co.	Search	Size and Wt	Too Large
AN/FPS-9	Armstrong Products Company	Doppler		Wrong Type
AN/FPS-10	General Electric Co.		Size and Wt	Too Large
AN/FPS-11		Search	Size and Wt	Too Large
AN/FPS-14	Bendix Aviation Corp	Search	Wt; Fixed Station	Too Large
AN/FPS-16	RCA	Tracking	C Band; Set-Up Time	Wrong Type; Wrong Band

Table 1-1. (Continued)

Nomenclature	Manufacturer	Radar Type	Limitations	Comments
AN/FPS-18	Bendix Aviation Corp	Search	Wt; Fixed Station	Too Large
AN/FPS-19	Raytheon Company	Dew Line	Wt; Fixed Station	Too Large
AN/FPS-20	Bendix Aviation Corp	Search	Weight	Too Large
AN/FPS-23	Motorola Communications and Electronics Inc.	Alarm System	Wt; Wrong Frequency	Needs Major Mod
AN/FPS-24	General Electric Co.	Sage Search	Size and Wt	Too Large
AN/FPS-28	Raytheon Company	Sage Search	Weight	Too Large
AN/FPS-30	Bendix Aviation Corp	Ground Search	Size and Wt	Not Transportable
AN/FPS-33		Dual Search	Size and Wt	Too Large
AN/FPS-35	Sperry Rand Corp	Sage Room Set	Size and Wt	Not Applicable
AN/FPS-36	Raytheon Company	Search	Size and Wt	Too Large
AN/FPS-37	General Electric Co.	Dual Search	Wt; Fixed Station	Too Large
AN/FPS-39				Cancelled by USAF
AN/FPS-40				Cancelled by USAF
AN/FPS-41		Weather Detecting		Wrong Type
AN/FPS-46	Bendix Aviation Corp	Fixed Ground		Not Transportable
AN/FPS-47				Cancelled by USAF
AN/FPS-49	RCA	Tracking	Weight	Wrong Type; Too Large
AN/FPS-51				Cancelled by USAF
AN/FPS-54	Martin Corp	Height Finder		Wrong Type
AN/FPS-57				Cancelled by USAF
AN/FPS-64		Dual Search	Size and Wt	Too Large
AN/FPS-65	Bendix Aviation Corp	Dual Search	Size and Wt	Too Large
AN/FPS-66	Bendix Aviation Corp	Dual Search	Size and Wt	Too Large
AN/FPS-67	Bendix Aviation Corp	Tracking and Search	Size and Wt	Too Large
AN/FPS-67A	Bendix Aviation Corp	Tracking and Search	Size and Wt	Too Large
AN/FPS-68	Curtis-Wright Corp	Weather Detecting	No MTI, IFF, ECCM	Not Applicable
AN/FPS-74	Bendix Aviation Corp	Ground	Weight	3 Years Availability Time
AN/FPS-501		Coastal Fire Control	X Band; Fixed Station	Wrong Band; Wrong Type
AN/FPS-502	Canadian Arsenals Ltd.	Search	No American Mfg	Unavailable in U.S.

Table 1-1. (Continued)

Nomenclature	Manufacturer	Radar Type	Limitations	Comments
AN/FPS-503	RCA, Canadian	Alarm System		Wrong Type; Needs Mod
AN/FPS-506		Alarm System	UHF Band	Needs Major Mod
AN/FPS-507		Height Finder	Size and Wt	Wrong Type
AN/FPS-508		Search	Size and Wt	Too Large
AN/GPA-17	Bendix Aviation Corp	Search	Size and Wt	Too Large
AN/GPA-23	General Electric Co.	Tracking		Wrong Type
AN/GPA-27	Bendix Aviation Corp	Search	Size and Wt	Too Large
AN/GPN-6	Laboratory for Electronics	Search	Requires Repackaging	Needs Major Mod
AN/GPS-3	General Electric Co.	Back-Up Search	Wt; Set-Up Time	Too Large
AN/GPS-4	Bendix Aviation Corp	Search	Size and Wt	Too Large
AN/GPX-6	Hazeltine Corp	IFF		
AN/GPX-7	Hazeltine Corp	IFF		
AN/GPX-8	Hazeltine Corp	IFF		
AN/GPX-9	Hazeltine Corp	IFF		
AN/GPX-11	Hazeltine Corp	IFF		
AN/GPX-12	Hazeltine Corp	IFF		
AN/GPX-13	Hazeltine Corp	IFF		
AN/GPX-14	Hazeltine Corp	IFF		
AN/GPX-17	Hazeltine Corp	IFF		
AN/GPX-18	General Electric Co.	IFF		
AN/GPX-19	Maryland Co.	IFF		
AN/GPX-20	General Electric Co.	IFF		
AN/GPX-26	Western Electric Co.	IFF		
AN/GSN-3		Automatic Landing		Wrong Type
AN/M-33	Western Electric Co.	Overall Surveillance		System Too Complex
AN/MPG-2		Tracking	X Band	Wrong Band; Wrong Type
AN/MPN-5	Bendix Aviation Corp	GCA	Size and Wt	Too Large
AN/MPQ-4	General Electric Co.	Mortar Locator		Needs Major Mod
AN/MPQ-4A	General Electric Co.			Needs Major Mod
AN/MPQ-4B	General Electric Co.			Cancelled by USAF

Table 1-1. (Continued)

Nomenclature	Manufacturer	Radar Type	Limitations	Comments
AN/MPQ-9				Wrong Type
AN/MPQ-10	Sperry Rand Corp	Tracking		Wrong Type
AN/MPQ-10A	Sperry Rand Corp	Tracking		Needs Major Mod
AN/MPQ-16		Tracking	Weight	Wrong Type
AN/MPQ-19		Tracking	X Band	Wrong Band; Wrong Type
AN/MPQ-24		Mortar Detector		Needs Major Mod
AN/MPQ-29	Sperry Rand Corp			Needs Major Mod
AN/MPQ-31		Tracking		Wrong Type
AN/MPQ-32	Sperry Rand Corp	Tracking		Wrong Type
AN/MPQ-35	Raytheon Company	Search	Wt; Requires Repackaging	Potentially Applicable
AN/MPQ-501				Needs Major Mod
AN/MPS-7	Bendix Aviation Corp	Tracking	Size and Wt	Needs Major Mod
AN/MPS-8	RCA	Height Finder		Wrong Type
AN/MPS-9	Reeves Instrument Corp	Tracking	No MTI	Wrong Type
AN/MPS-11	General Electric Co.	Search	Size and Wt	Too Large
AN/MPS-16	AVCO	Height Finder	C Band	Wrong Band; Wrong Type
AN/MPS-20	Westinghouse Electric Corp	Height Finder		Wrong Type
AN/MPS-21	Sperry Rand Corp	Height Finder	Size and Wt	Wrong Type; Too Large
AN/MPS-22		Tracking		Wrong Type
AN/MPS-23	Hughes Aircraft Co.	Tracking	Wt; Pencil Beam Scan	Wrong Type
AN/MPX-7	Ultrasonic Corp	IFF		
AN/MSQ-1	Reeves Instrument Corp	Tracking	Weight	Wrong Type; Too Large
AN/MSQ-18	Hughes Aircraft Co.	Tracking		Wrong Type
AN/MSQ-35	Raytheon Company	Search		Similar to MPQ-35
AN/PPS-4	Sperry Rand Corp	Doppler		Wrong Type; Not Applicable
AN/PQ-29	Sperry Rand Corp	Tracking and Control	X Band	Wrong Band; Wrong Type

Table 1-1. (Continued)

Nomenclature	Manufacturer	Radar Type	Limitations	Comments
AN/SCR-584		Tracking		Wrong Type
AN/SPN-8	Bendix Aviation Corp	Approach System	X Band	Wrong Band; Wrong Type
AN/SPS-6	Westinghouse Electric Corp	Search	Weight; No MTI	Obsolete
AN/SPS-6C	Westinghouse Electric Corp		No MTI	Not Applicable
AN/SPS-8	General Electric Co.	Height Finder		Wrong Type
AN/SPS-8D	General Electric Co.	Shipboard Radar		Wrong Type
AN/SPS-10	Sylvania Electronic Systems		C Band	Wrong Band
AN/SPS-12	RCA	Search	Weight	Too Heavy
AN/SPS-16	Westinghouse Electric Corp	Search		Not "Off-The-Shelf"
AN/SPS-17		UHF	Size and Weight	Wrong Band; Wrong Type
AN/SPS-21			C Band	Wrong Band
AN/SPS-23	RCA	Shipboard Search	X Band	Wrong Band; Wrong Type
AN/SPS-26				Discontinued
AN/SPS-28	Westinghouse Electric Corp	Search	P Band; Size and Wt	Wrong Band; Too Large
AN/SPS-29	Westinghouse Electric Corp	Search	P Band; Size and Wt	Wrong Band; Too Large
AN/SPS-30				Wrong Band
AN/SPS-32	Hughes Aircraft Co.	Surveillance	MC Band	Wrong Band; in Development
AN/SPS-33		Search	MC Band	Wrong Band
AN/SPS-37	Westinghouse Electric Corp	Search	P Band	Wrong Band
AN/SPS-39	Hughes Aircraft Co.	Height Finder		Wrong Type
AN/SPS-39A	Hughes Aircraft Co.	Height Finder		Wrong Type
AN/SPS-43	Westinghouse Electric Corp	Search	P Band	Wrong Band

Table 1-1. (Continued)

Nomenclature	Manufacturer	Radar Type	Limitations	Comments
AN/SPS-48		3D		Not Applicable
AN/SPS-49	Bendix Aviation Corp	Shipboard		Wrong Type
TARMAC	Texas Instruments, Inc.	Search		Same as ASR-4
AN/TPN-8		GCA	X Band	Wrong Band; Wrong Type
AN/TPN-12	Laboratory for Electronics	GCA	X Band	Wrong Band; Wrong Type
AN/TPS-1D	Raytheon Company	Search		Similar to TPS-1G
AN/TPS-1G	Hazeltine Corp	Search		Potentially Applicable
AN/TPS-10	Raytheon Company	Height Finder		Wrong Type
AN/TPS-15X		IFF		Made up of TPX-15 and TPS-1G
AN/TPS-22	Westinghouse Electric Corp	Search	Size and Wt	Too Large
AN/TPS-27	Westinghouse Electric Corp	Search and Height	Weight	Wrong Type; Too Large
AN/TPX-17	General Electric Co.	IFF		
AN/TPX-18	General Electric Co.	IFF		
AN/TPX-19		IFF		
AN/TPX-26		IFF and SIF		
AN/TSQ-18	Gilfillan Bros. Inc.			AN/UPS 1 + GCA
AN/UPA-24		SIF Decoder		Used with AN/TSQ-18
AN/UPS-1	RCA	Search		Potentially Applicable
AN/UPX-6	Radio Receptor Co.	IFF		
AN/UPX-11		IFF		Used with TSQ-18

Table 1-2. System characteristics of recommended search radars

Characteristics	A4W Spec.	ASR (MPN-11 MOD)	ASR-4 MOD.	HAWK	TPS-1G	UPS-1A
Peak Power	500 kw	750 kw	425 kw	550 kw	500 kw	1 megawatt
Frequency	"L"or"S"	2780-2820"S"	2700-2900"S"	1250-1350"L"	1220-1350"L"	1280-1350"L"
Average Power		570 watts	432 watts	1320 watts	400 watts	1120 watts
Pulse Width	1 μsec	0.7 μsec	0.83 μsec	3 μsec	2 μsec	1.4 μsec
Duty Cycle		.00077	.00096	.0024	.0008	.00112
Range 1 sq. meter	70 nm	60 nm	70 nm	75 nm	66 nm	80 nm
Receiver Noise Fig:	8 db	10 db	8 db	8 db	9.5 db	9 db
Normal with Param. Ampl.	3 db	4 db	4 db	None	None	4 db
Receiver MDS Figure		-105 dbm	-102 dbm	-107 dbm	-105 dbm	-105 dbm
MTI Subclutter Visibility	35 db	20 db	25 db	29 db	26 db	30 db
MTI Range	70 nm	60 nm	70 nm	65 nm	66 nm	80 nm
Antenna Gain	30 db	29.6 db	34 db	27 db	26 db	27 db
Antenna RPM	12 rpm	15 rpm	15 rpm	20 rpm	15 rpm	15 rpm
Antenna Blip/Scan % 60 nm 1 sq. meter	Not spec	75	65	75	75	75
Top Coverage (alt in ft)	45k ft at 45^o	50k ft at 45^o	40k ft at 35^o	50k ft at 45^o	35k ft at 32^o	50k ft at 35^o
Azimuth Coverage	360^o	360^o	360^o	360^o	360^o	360^o
Azimuth Accuracy	Not spec	1%	1%/500'	$\pm 1/2^o$	1%	$\pm 1^o$
Reflector Dimensions		10'x3.3'	17.5'x9'x6'	22'x5'	15.7'x6.2'	16'x4.7'
Beamwidth	1.5^o	2.5^o	1.5^o	2.8^o	3.4^o to 4^o	3.5^o
Beam Pattern	csc^2	csc^2	csc^2	csc^2	$10^o - 12^o csc^2$	csc^2
Hits per Beam Width	15	30	18	18-1/2	14.5	33

Table 1-2. (Continued)

Characteristics	A4W Spec.	ASR (MPN-11 MOD)	ASR-4 MOD.	HAWK	TPS-1G	UPS-1A
Reliability MTBF	320 hrs	Unknown	Unknown	Unknown	250 hrs	150 hrs
Endurance	23 hrs on/day	23 hrs on/day	23 hrs on/day	23 hrs on/day	23 hrs on/day	23 hrs on/day
Applicable MIL Spec	MIL-E-4158	MIL-E-4158B	FAA-R-864 FAA-777C	MIL-11991 MPD-SD-130	MIL-R-0015895D	MIL-E-16400
Test Equip. Incl.		"A" Scope and Perf. Mon.	"A Scope/ PPI Scope	"A"Scope PPI Scope	"A"Scope/ PPI PPI Scope Echo Box	"A"Scope/PPI Scope Echo Box/ Perf. Mon Proposed
Clutter Circuits						
FTC		Present	Present	None	Present	Present
STC		Present	Present	None	None	Present
PWD		Present	None	None	None	Present
IAGC		None	Present	·	None	None
Video Int.		Proposed	Present	Present	None	Kit Form
Cir. Pol.		Present	Present	None	None	None
Other		Proposed Clutter Gated Video Sw	Pre-Selector Filter	None	None	Kit Form-Log FTC IF
Anti-Jam						
Dicke Fix		Proposed		Present	None	Kit Form
Side Lobe Blanker		None	None	Present	None	Kit Form
Tunable Magnetron		None	Present	Present	Present	Present
RCVR Back Bias		None	None	Present	None	None
Video Correlator		Proposed	None	None	None	None
Other		None		None	Adj. Prf	CFAR

Table 1-2. (Continued)

Characteristics	A4W Spec.	ASR (MPN-11 MOD)	ASR-4 MOD.	HAWK	TPS-1G	UPS-1A
Primary Power		120/208 60 cps, 3ϕ	120/208 60 cps, 3ϕ	416v 400 cps, 3ϕ	115v 400 cps, 1ϕ	120/208 400 cps, 3ϕ
System Gross Wt. Unshel.		2900 lbs.	4800 lbs.	4200 less TRLR	3000	2066
Sheltered		4840 lbs. Incl. Ant. Case	Refer to Paragraph 2.2.1	5067 in HUT	4500	3750
Shelter and Auxil.		94"h x 76"w x 120"l 72"h x 36"w x 122"l		90"h x 114"w x 180"l	98"h x 78"w x 102"l 86"h x 110"w x 59"l	102"h x 118"w x 102"l 96"h x 71"w x 65"l
Shelter Heat Dissipation		6.4kw(21.9k Btu/hr.)	12.5kva (32 kBtu/hr.)	9.6kw(32k Btu/hr)	5kw(17.2k Btu/hr.)	6kw(20.5k Btu/hr.)
Total Repeaters without MOD/		3	3	3	3	3
Set-up Time		3 man hrs.	12 man hrs.	1/2 man hr..	3 man hrs.	3 man hrs.
Environmental Specs. (Oper.) Ambient Temp. Oper./HWM		-65° to 160°F/ 95%H	14° to 122°F/ 98% H		-65° to 135° F/95% H	-65° to 165°F/ 95% H
Altitude-Oper./NonOper.		6500 ft/ 35000 ft	14° to 122°F/ 98% H		8000 ft/ 30,000 ft	10,000 ft/ 40,000 ft
Wind-Oper/Non Oper.		60mph/100mph	100mph	87mph	60mph/90mph	60mph/115mph
Availability-Lead-Time		In Prod.	9 months	In Prod. 8 mo Lead	Mid '62	Mid '62

1.3 MODIFICATIONS REQUIRED FOR EMERGENCY MISSION SUPPORT (EMS)

After selecting an available radar that meets the requirements for the EMS System, it was still necessary to recommend certain modifications to adapt the "off-the-shelf" radar system to the EMS System. Many remote control circuits had to be incorporated in the receiver and circular polarization had to be included. In the IFF trigger, specially designed time delay circuits were included to compensate for the 15-mile remoting distance. A different type sensitivity time control circuit was required for air traffic control and incorporated into the AN/TPS-35. Resolvers were required by the microwave remoting system and were recommended to replace synchro units in the existing system. Automatic reset circuits were incorporated to conform to the automatic primary power transfer system. And, finally, some minor changes were recommended to the existing radar to make it more desirable for air traffic control use, as well as a remote, non-manned station.

SECTION 2

RADAR SET AN/TPS-35

2.1 GENERAL DESCRIPTION

The AN/TPS-35 is a lightweight-sheltered Search Radar System used as an air traffic control device as part of the AN/TSQ-47 Air Traffic Control and Communications System. The AN/TPS-35 contains a high performance search radar group, a microwave remoting group, a UHF Air/Ground/Air communication group, an interfacility communications group, AN IFF/SIF identification group, and a power generator and air conditioner group.

2.1.1 FUNCTION

The function of the AN/TPS-35 is to provide two dimensional, aircraft present position data on small cross-section aircraft at ranges up to 80 nautical miles with provisions up to 275 nautical miles if required. This must be accomplished in a search mode in the presence of weather clutter and friendly and unfriendly interference. The AN/TPS-35 also supplies interrogation pulses to the aircraft to enable the proper identification of the aircraft by the system. The AN/TPS-35 supplies the aircraft position information to the main control room (RAPCON), which may be as much as 15 miles away. The remote control and data signals are transmitted and received over the path by the use of an electronic microwave remoting system. All the necessary signals required for operation are carried by the microwave system to increase the flexibility of the AN/TPS-35 Search Radar System.

2.1.2 AN/TPS-35 INDEPENDENT OPERATION

The Radar System, AN/TPS-35, is capable of operating without the use of the AN/TSQ-47 System if it is ever required. By use of the UHF

communications and the self-contained SIF/IFF equipment, the Search Radar System may be sent out as a self-contained unit.

2.1.3 SEARCH RADAR DESCRIPTION

The AN/TPS-35 Search Radar Unit contains a parametric amplifier to increase system performance; a Frequency Modulated (FM) Moving Target Indicator (MTI) unit to provide better stability over the conventional amplitude modulated MTI units; improved Sensitivity Time Control (STC) to provent clutter out to 80 nautical miles if required; a pulse width discriminator unit designed to operate on both the normal radar receiver and the MTI receiver to prevent undesirable friendly interference; a fast-time constant circuit to breakup large clutter blocks; a video sweep integrator unit used on the 275-mile range to increase intensity of very weak targets; a PRF stagger circuit to mark undesirable second-time-around targets; a circular polarization system to eliminate rain clutter from the radar presentation; and a complete ECCM System to prevent unfriendly interference from putting the Search Radar System out of operation.

2.1.4 MICROWAVE REMOTING DESCRIPTION

The AN/TPS-35 Radar System contains a complete electronic remoting system. The microwave system contains all the necessary multiplex equipment, receivers, transmitters, power supplies, antenna and diplexing equipment to receive 9 control functions, the beacon trigger and transmit, radar trigger, normal video, MTI video, IFF video, and order wire information over a 15-mile path if required.

2.1.5 IFF/SIF GROUP DESCRIPTION

The AN/TPS-35 Search Radar System contains the necessary ground interrogation electronic equipment to make it compatible with existing airborne SIF/IFF Mark X identification systems. The AN/TPS-35

system, when used in conjunction with the AN/TSW-5 RAPCON unit, contains: 1 receiver/transmitter AN/UPX-6; 1 coder synchronizer KY-84; 4 video decoders KY-364; and the necessary RF cable and power supplies to operate in conjunction with the AN/TPS-35 search radar group.

2.1.6 AIR/GROUND/AIR/COMMUNICATION GROUP

The AN/TPS-35 Search Radar System contains one UHF ARC-52 communication system to be used as an Air/Ground/Air Communication Set. The ARC-52, complete with control head and antenna, AT-197 operates in the 225.0 to 399.9 Mc range and has the capability of 1750 manual selected frequencies available to an operator.

2.1.7 INTERFACILITY COMMUNICATION

The AN/TPS-35 Search Radar System contains one VHF pulse code, full duplex, transmitter and receiver to be used for intercommunication between this site and the main AN/TSQ-47 System site. The VHF transceiver utilities the random access and correlation for extended performance discrete address system (RACEP) which will work in conjunction with idential RACEP units throughout the AN/TSQ-47 System.

2.1.8 POWER GENERATOR GROUP

The AN/TPS-35 Search Radar System contains two gasoline turbine power generators, each supplying 3 phase, 4 wire, 115/208 volts ac, 400 cps, 20 kw power to the radar system and the air conditioning unit. One of the generators is held in reserve to be used when required.

2.1.9 AIR CONDITIONER

One air conditioner is supplied with the AN/TPS-35 Radar System to maintian a correct operating temperature for the electronic equipment located within the shelter. The air conditioner is rated at 2.8 tons

and operates from the main 400 cps, 3-phase power source. The total weight of the unit is less than 250 pounds.

2.2 DETAIL DESCRIPTION

2.2.1 RECEIVER GROUP

(This Confidential Section is bound under separate cover as a supplement to this report.)

2.2.2 INDICATOR GROUP

A. The Azimuth-Range Indicator is the unit from which the radar system is controlled and operated after application of main power. The unit contains the various control circuits necessary for effecting the remote functions of antenna rotation control, magnetron and system tuning transmitter pulse width, pulse repetition frequency, receiver bandwidth, A-J control, and interference blanking. The unit receives MTI, normal, and IFF video; antenna position synchro data; and system trigger pulse; from which data it presents the 20-, 40-, 80-, and 275 mile range displays on a 10-inch PPI-Scope and a 3-inch A-scope. It also provides remote trigger, remote video, and special video data for remote repeaters and/or indicators. Operator controls and displays are on the front panel. (See Figure 2-1)

The list of controls and their functions in Table 2-1 are those which may require frequent adjustment. Other operational and maintenance controls are positioned separately. Maintenance controls are located behind a hinged plastic cover to protect them from accidental misalignment. The controls most often used are fabricated and positioned in a manner that complies with good human engineering practice.

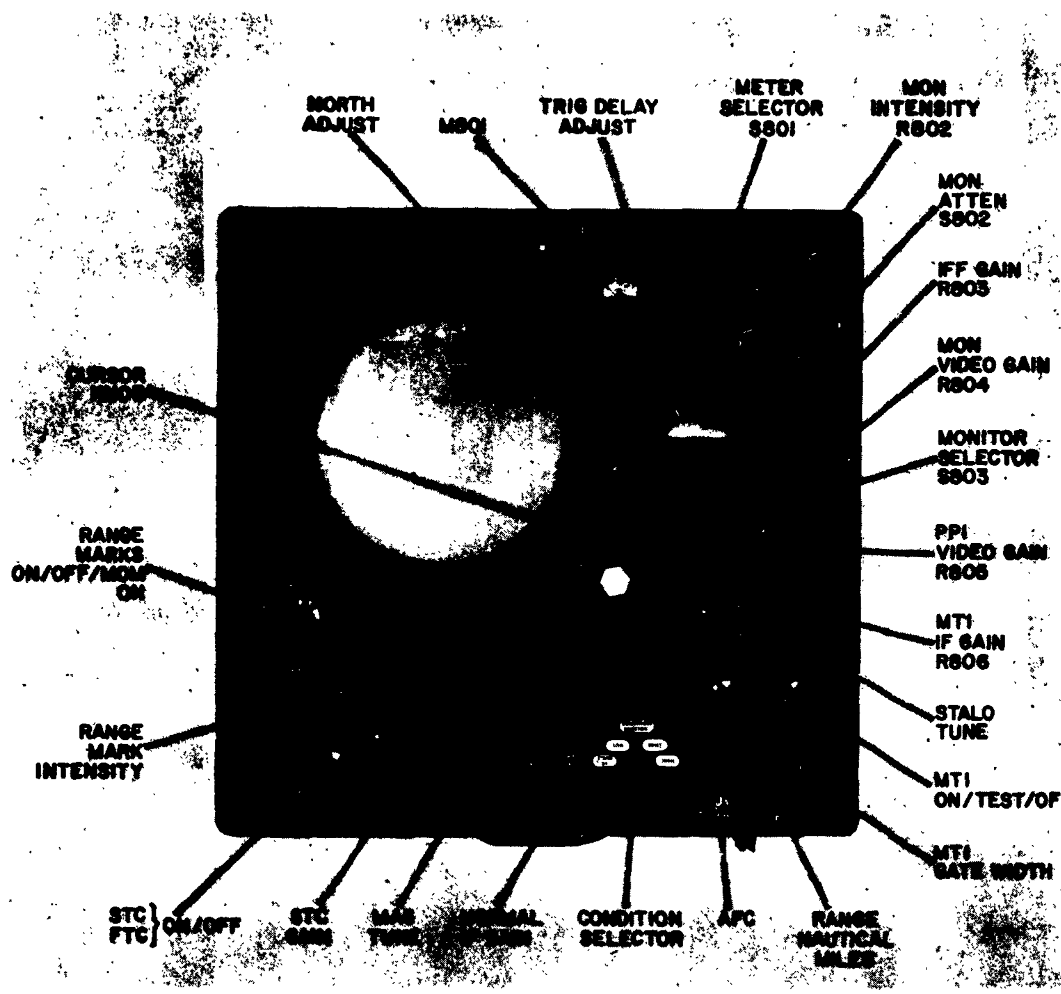


Figure 2-1. Azimuth-Range indicator

Table 2-1 Front panel controls

Control	Knob Shape	Function
Condition selector	Rounded bar	Places radar set in one of four power conditions (Standby, Low Power, Reset, High)
AFC	Toggle	Selects tuning means of magnetron, parametric amplifier assembly, and stalo.
Mag tune	Toggle	Adjusts magnetron frequency
Stalo tune	Toggle	Adjusts stalo frequency (in manual)
Antenna Speed	Octagon	Adjusts antenna rotational speed (in search)
Anti Jam	Bar	Selects STC, FTC, on or off
STC Gain	Triangle	Adjusts level of STC curve
Normal Gain	Fluted	Adjusts normal IF gain
MTI Gain	Slot	Adjusts MTI IF gain
MTI Gate	Rounded bar	Adjusts MTI presentation period
Range (NM)	Bar	Controls PRF of radar Selects operating range of PPI (20, 40, 80, 275 NM)
Cursor Knob	Hand Wheel	(1) In searchlight operation, positions antenna, PPI sweep and cursor line. (2) In search operation controls cursor line only.

Table 2-1 Front panel controls - continued

Control	Knob Shape	Function
North Adjust	Slot	Rotates shaft of differential synchro to add or subtract angular position from indicator servo system, to compensate for site position of radar set off north.
Meter Select	Bar	Selects one of nine inputs to panel meter.
IFF Gain	Bar	Adjusts IFF IF video gain
Range Marks Intensity	Triangle	Adjusts range marks intensity on PPI
MTI Test-Normal	Bar	Selects presentation of MTI or normal video on PPI
PPI intensity	Triangle	Adjusts PPI baseline intensity
PPI video	Fluted	Adjusts PPI video signal intensity
Monitor selector	Bar	Presents one of twelve inputs on the monitor A-Scope
"A" video gain	Fluted	Adjusts A-Scope vertical amplitude
"A" intensity	Triangle	Adjusts A-Scope intensity
Trigger Delay adjust	Bar	Adjusts delay to start of sweep on A-Scope (variable)
"A" Scope input attenuator	Toggle	Places 10:1 attenuator in probe circuit
Cursor dimmer	Ext round	Adjusts cursor lamp illuminating level
Panel dimmer	Slot	Adjusts panel lamp illumination level

Provision is incorporated on the Range Switch to prevent accidental selection of the 275-mile operating mode. Incorporation of a spring-loaded catch device makes a deliberate action necessary to operate the switch.

All controls not mounted on the front panel of the indicator are located on an easily accessible sub-panel inside the front panel, or on the module board pertinent to the circuit. These are adjustment and calibration controls.

Normal, STC and MTI gain controls: to prevent mistuning by duplicate controls, the potentiometers in the indicator will be retained. The selection of remote or local operation will actuate relays in the junction box that either feeds signal from potentiometers located there for remote operation or feeds the voltages from the indicator to the receiver for local operation. An added advantage of this approach is the return of the receiver operation to exactly the same condition when the system is returned from local to the remote mode of operation. A lamp on the front panel of the indicator will reveal the remote/local condition at all times.

The indicator circuitry implements the following functions:

Generate range marks
Generate PPI sweep
Generate A-scope sweep
Mix video and range markers
Amplify video for remoting
Generate gate for gating MTI and normal video
Provide 360 degree sweep rotation synchronized with antenna speed
Provide built-in monitoring circuits for A-scope presentation
Amplify video by special video amplifier.

The overall block diagram of the indicator is shown in Figure 2-2. (For the pulse width discriminator see the Confidential Supplement to this report.) The PPI display circuits include the variable gate generator, video mixer, interference blanker and video range marks mixer and amplifier. The PPI sweep circuits include the main gate generator and PPI sweep generator. The indicator (yoke) servo and antenna servo error components include synchro control, speed and manual control, and yoke servo. Monitor A-Scope circuits include selector switch, A-scope vertical amplifier, delayed trigger circuit, and sweep generator.

B. Technical Discussion

The following is a discussion of the PPI display circuits, indicator servo and antenna servo error circuits, monitor A-scope circuits, and power supply.

a. PPI Display Circuits

A block diagram of the PPI display circuits is shown in Figure 2-3. Normal video and MTI video from the receiver and IFF video from IFF equipment are fed into the variable gate generator and video mixer A810. This module will gate any MTI video from 5 to 80 miles range through to the video mixer. The normal video will pass through for the ungated portion. The video mixer will mix the IFF video and the gated MTI and normal video. The mixed video passes through a 2-microsecond delay line to the interference blanker A809. The interference blanker is triggered by neighboring friendly radars, whose transmissions would cause interference. The A809 module generates a gate to blank the video during such periods. The 2-microsecond delay line is used to delay the video by the amount equal to that which triggers from the friendly radars would be delayed by traveling through 1000-foot coaxial cables. The video output of the A809 module is applied

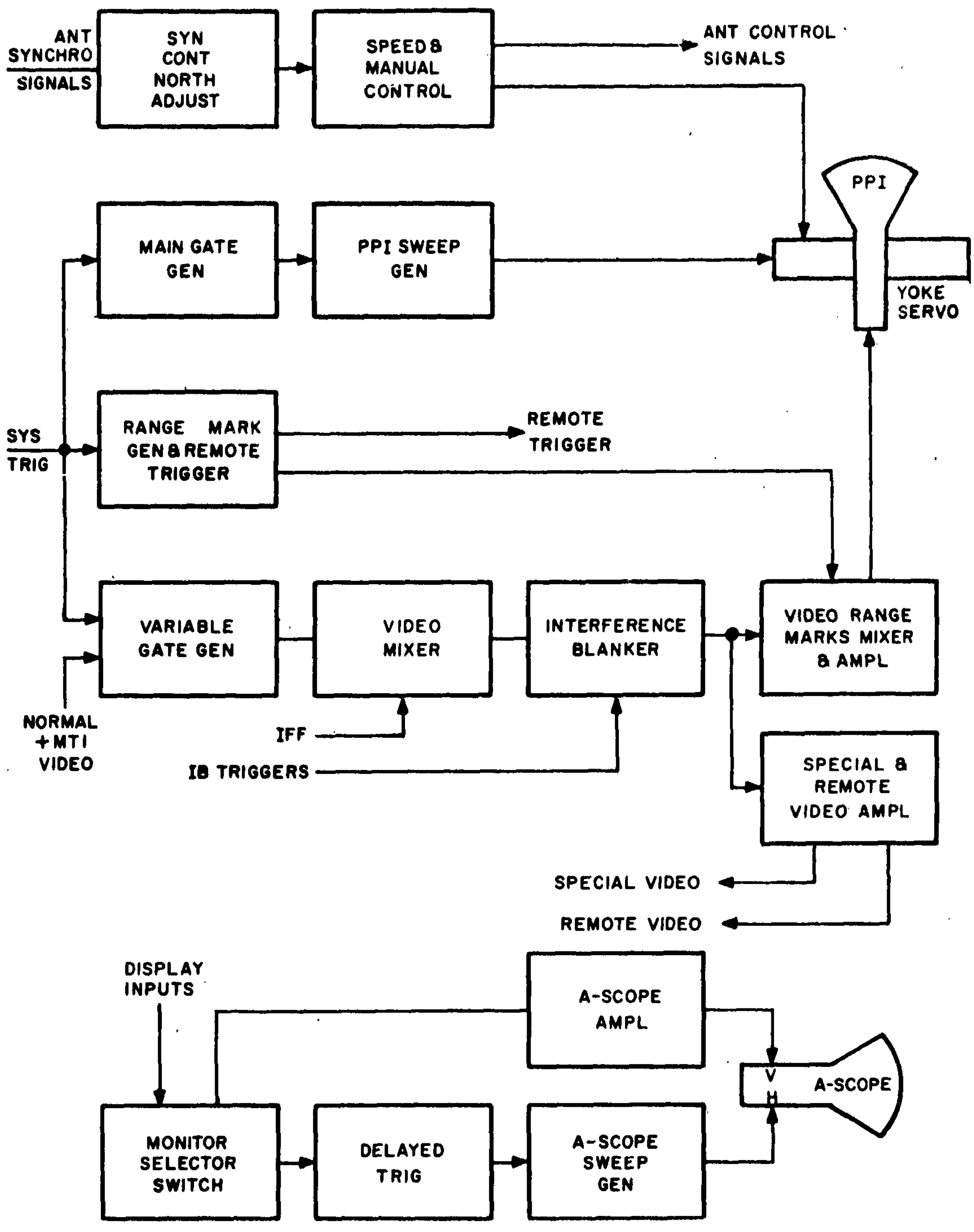


Figure 2-2 Azimuth-Range indicator, block diagram

to the remote and special video amplifier A808, and to the PPI video and range marker mixer and amplifier A804. The former provides remote and special video outputs to remote repeaters. The A804 module provides the mixed video to the indicator PPI tube. Radial sweep voltages for the PPI display are generated in PPI sweep generator A803, the sweep and unblanking being gated by main gate generator A801. Range mark generator A802 generates pulses to cause range marks on the display for determining target range. The pulses are fed to the A804 module. The remote trigger circuit on A802 produces a low-impedance remote trigger output of 50 volts minimum amplitude. The A802 range marks are gated by main gate generator A801.

b. Indicator (Yoke) Servo and Antenna Servo Error Circuits

These circuits and their connection to other servo system components are shown in Figure 2-4. The antenna servo has two modes of operation: search and searchlite. The indicator or yoke servo rotates the PPI yoke to positions corresponding to the antenna positions.

1. Search mode - With the indicator front panel cursor knob pushed in, the voltage output of the variable speed control will be connected to antenna servo error amplifier A811. The output of the A811 connects to the servo amplifier in the main power supply, which connects to the antenna drive motor. Antenna tachometer feedback to the A811 closes a velocity servo loop, which maintains the antenna running at constant speed. A synchro control transmitter mounted to the antenna pedestal sends back position information to the synchro control A817 in the indicator. The A817 is a differential synchro for setting the initial alignment of the PPI sweep to the antenna position whenever the radar system is relocated. The output of the synchro control A817 connects to the yoke servo synchro. The error output from the yoke synchro amplified by the servo amplifier A811 drives the yoke servomotor, which continually positions the yoke to the antenna position.

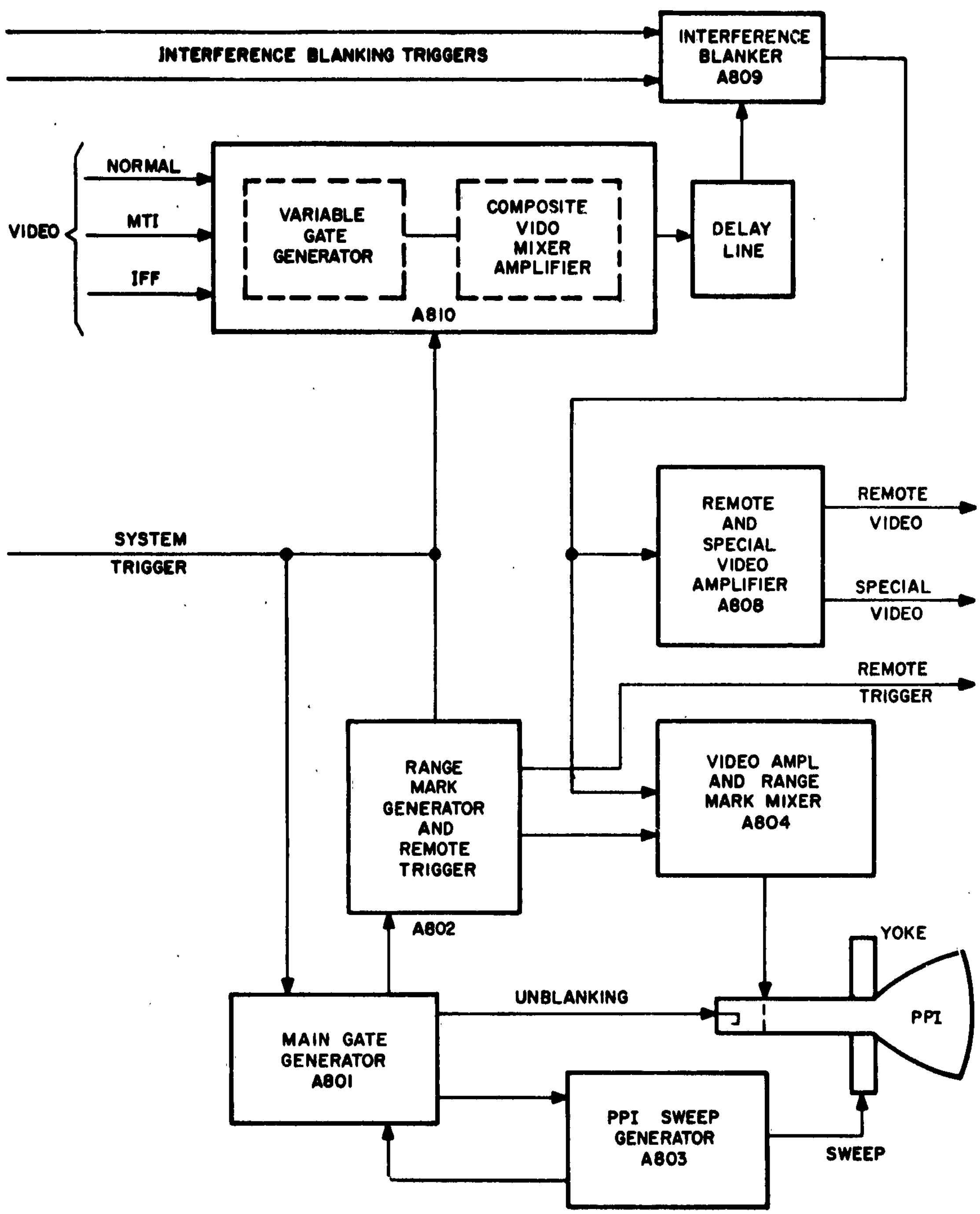


Figure 2-3. PPI display circuits

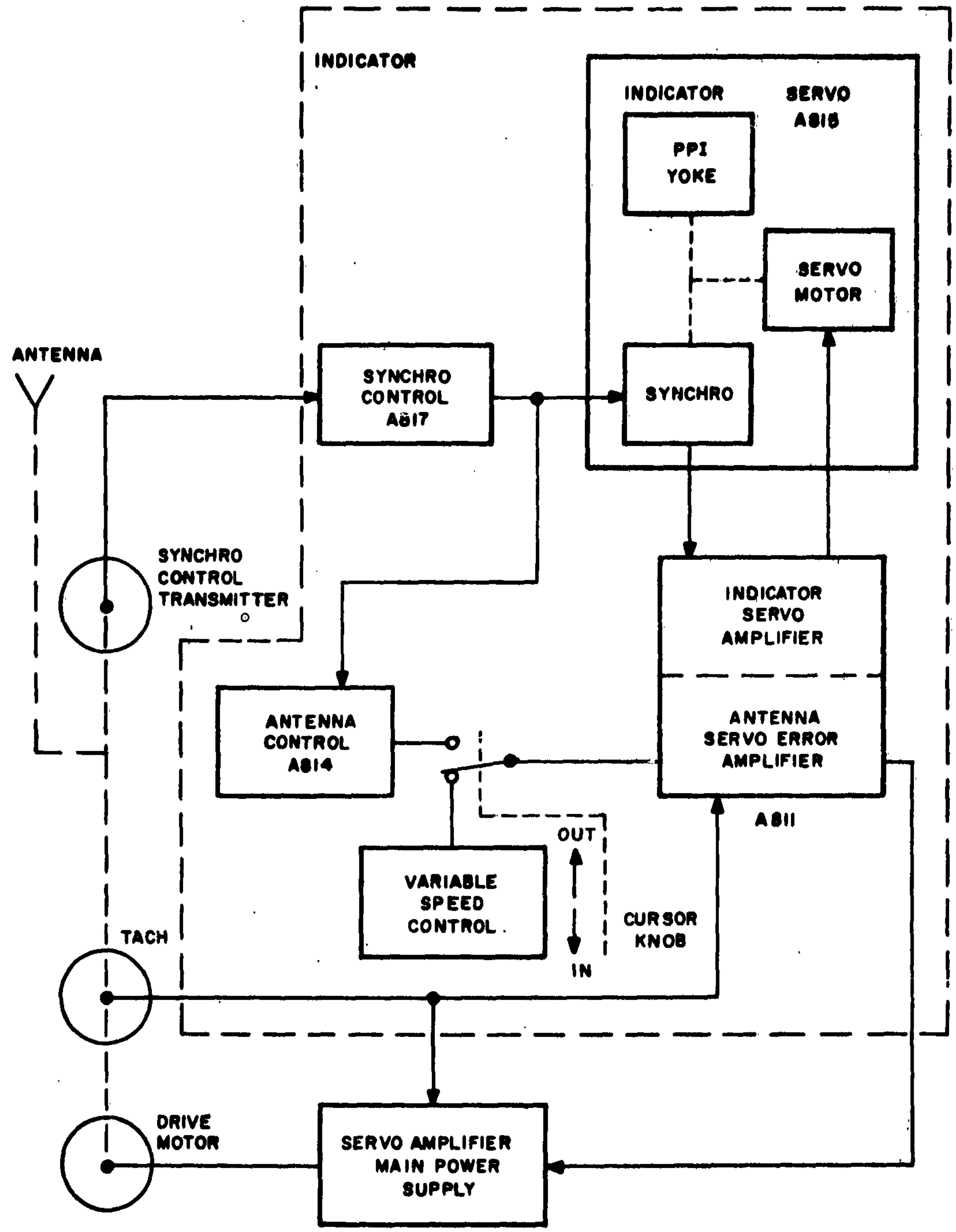


Figure 2.4. Indicator Servo and Antenna Servo

2. Searchlite mode - With the indicator front panel cursor knob pulled out, signals from the antenna control synchro A814 will position the antenna through the servo loop formed by antenna servo error amplifier A811, the servo amplifier in the main power supply, the antenna drive motor, the antenna synchro control transmitter, and the synchro control A817. The indicator servo will function as described above, receiving its error signals from the antenna synchro transmitter through the synchro control A817. Antenna control A814 synchro receives its position information from the hand-wheel control on the indicator front panel, which also drives the PPI cursor line.

c. Monitor A-Scope Circuits

These circuits are shown in block diagram form in Figure 2-5. The 3-inch A-scope on the front panel of the indicator is provided to monitor and service the equipment. The following signals can be displayed: the PPI sweep, range marks, system trigger, normal video, MTI video, PPI video, and indicator (Yoke) servo error. Other signals may be displayed through an external probe connected to the "test-probe" connector on the indicator front panel. Three modules and indicator front panel controls constitute the circuitry associated with the monitor. Trigger delay generator A805 provides a continuously variable delayed trigger pulse to the horizontal sweep circuit of the A-scope when the monitor selector switch is in any external test probe position. Video amplifier A806 provides amplification of video signals to provide vertical deflection on the monitor display. Sweep generator A807 provides horizontal deflection voltages and unblanking pulses for the monitor.

d. Power Supply

The power supply assembly A816 for the indicator contains voltage regulator module A812. The inputs required are

120 volts 400	4.2 amps nom.
+350 volts dc	8 ma. nom.

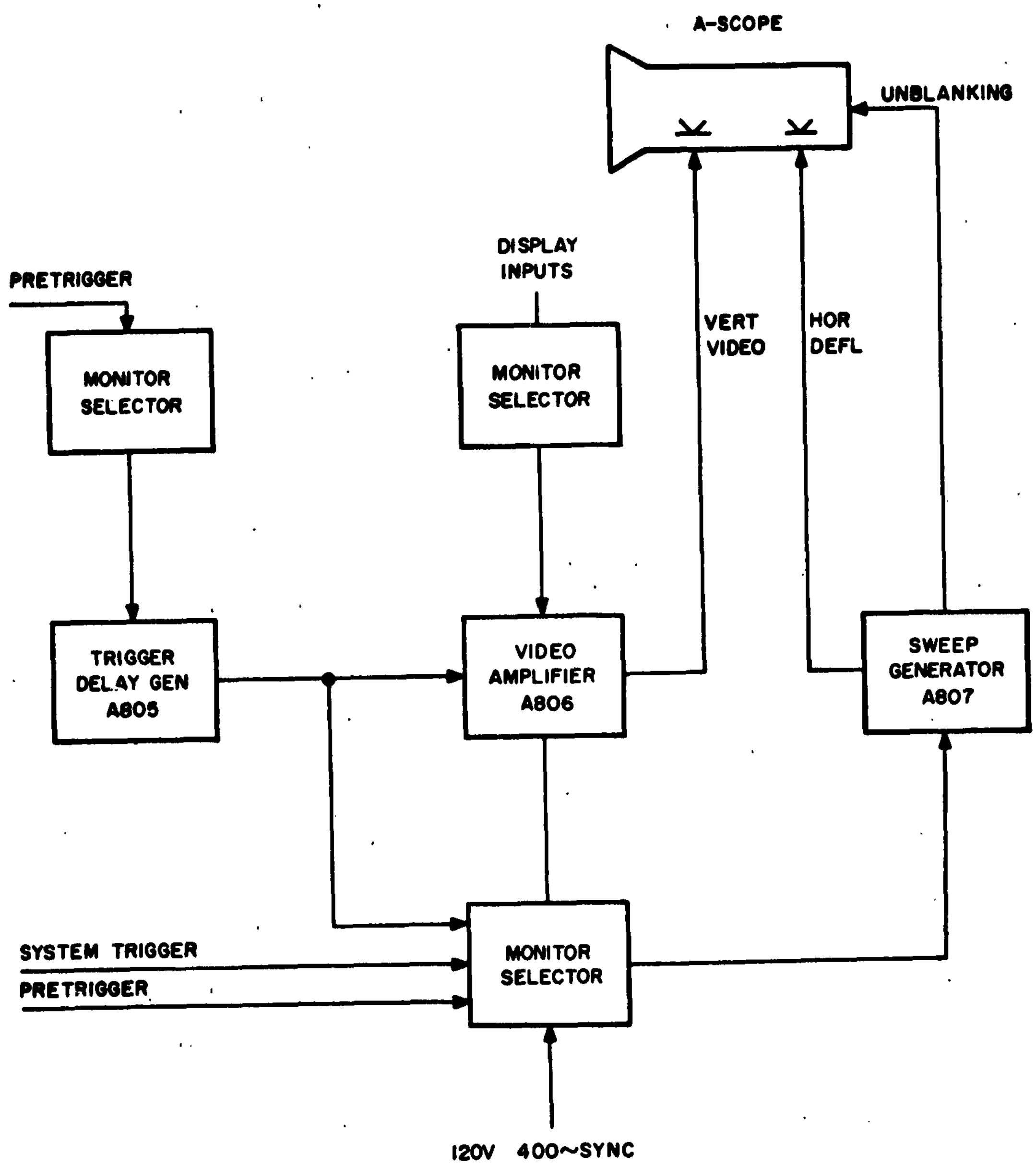


Figure 2-5. Monitor A - scope circuits

The outputs will be

6.3 volts 400 ~	6 amps max.
-200 volts dc regulated	65 to 95 ma
+150 volts dc regulated	250 to 350 ma
-1100 volts dc	1.5 ma. max.
+7000 volts dc	0.15 ma. max.
+350 volts dc	8 ma. nom.

C. Mechanical Discussion

The cabinet of the azimuth-range indicator is vibration isolated . The chassis can be withdrawn on its own slides from the cabinet for servicing or adjustment. The power supply A816 is mounted on a vertical hinge at the right side of the chassis and swings forward for top-of-chassis access. The voltage regulator module A812 is mounted on a hinged connector on the power supply chassis and swings out for module withdrawal. The indicator (yoke) servo A814 is mounted so as to encompass the neck of the PPI tube. The eleven remaining modules A801 to A811 and the adapter module A813 are vertically supported in a module nest on the left side of the chassis.

The antenna control assembly A814 is mounted on the indicator front panel. Synchro control (north Adjust) A817 is mounted on the indicator subpanel adjacent to the face of PPI tube. Circuit comp ents (resistors, capacitors, etc.) are mounted on a shelf along the top of the chassis.

D. Maintainability and Serviceability

Twelve of the sixteen major assemblies are plug-in modules. The wiring to the yoke drive and the power supply assmeblies are removed by connectors. The synchro control and antenna control assemblies have wiring connected to screw-type terminals. The entire indicator

chassis can be drawn out of the case on the chassis slides. Sufficient adjustments are contained in the indicator for periodic alignments to allow for aging of components. All subminiature tubes are plug-in.

The monitor can be selected to view various key points in the indicator circuitry for trouble shooting. Test points are available on each plug-in module for servicing. In addition, adapter module A813 can be used to extend any module out of the module nest for servicing.

E. Reliability

Based on prediction and test data, the MTBF is 520 hours.

2.2.3 MODULATOR/TRANSMITTER GROUP

A. General

The function of the modulator transmitter is to provide pulsed RF power output, continuously tunable during operation over the band from 1250 megacycles to 1350 megacycles. Two pulse width/PRF combinations are required to accommodate short-range medium-resolution radar coverage or long-range lower-resolution coverage. Pulse width and PRF are arranged to keep average power output essentially constant (1.4 microseconds/800 pps or 4.2 microseconds/267 pps).

Auxiliary functions include integral metering circuits and circuits to prevent equipment damage in the event of circuit, magnetron, or overheating faults.

Features include an elevator mechanism to facilitate magnetron installation and removal, convenient test points and monitoring points, auxiliary test trigger outputs, and viewing window for main hydrogen thyratron.

The group will provide a stable output pulse consistent with specified MTI performance while minimizing magnetron selection. The group will operate reliably within the detailed specifications discussed below and in the presence of a rigorous environment.

The equipment group constitutes a minor redesign of the production equipment shown in Figure 2-6. The equipment shown is part of the existing AN/UPS-1 production radar. Minor changes of a mechanical nature are all that are required to fulfill the AN/TPS-35 requirements. These are: addition of ducting for positioning the two blowers outside of the AN/TPS-35 shelter, and removal of the oil reservoir for mounting on the shelter wall. The magnetron for the modulator/transmitter is the RK6517/QK358.

B. Overall Block Diagram

Figure 2-7 diagrams the individual functions of the modulator transmitter group.

C. Description of Operation

Prime input power of 8500 volts at 0.4 amperes dc (nominal) is supplied to the modulator/transmitter from the modulator power supply. The main pulse forming network is charged to approximately 17,000 volts peak through the charging reactor and the charging diode. Network charging from the 8500 volt dc supply follows the usual resonant charging waveform, except that the presence of the charging diode "holds" the charge at its peak value until the pulse is triggered. Inclusion of a charging diode (1) allows the charging reactor to be a simple, less critical design, (2) eliminates a high voltage pole on the pulse switching relay, and (3) improves MTI performance by eliminating a component of amplitude jitter caused by residual charging current in the charging reactor.

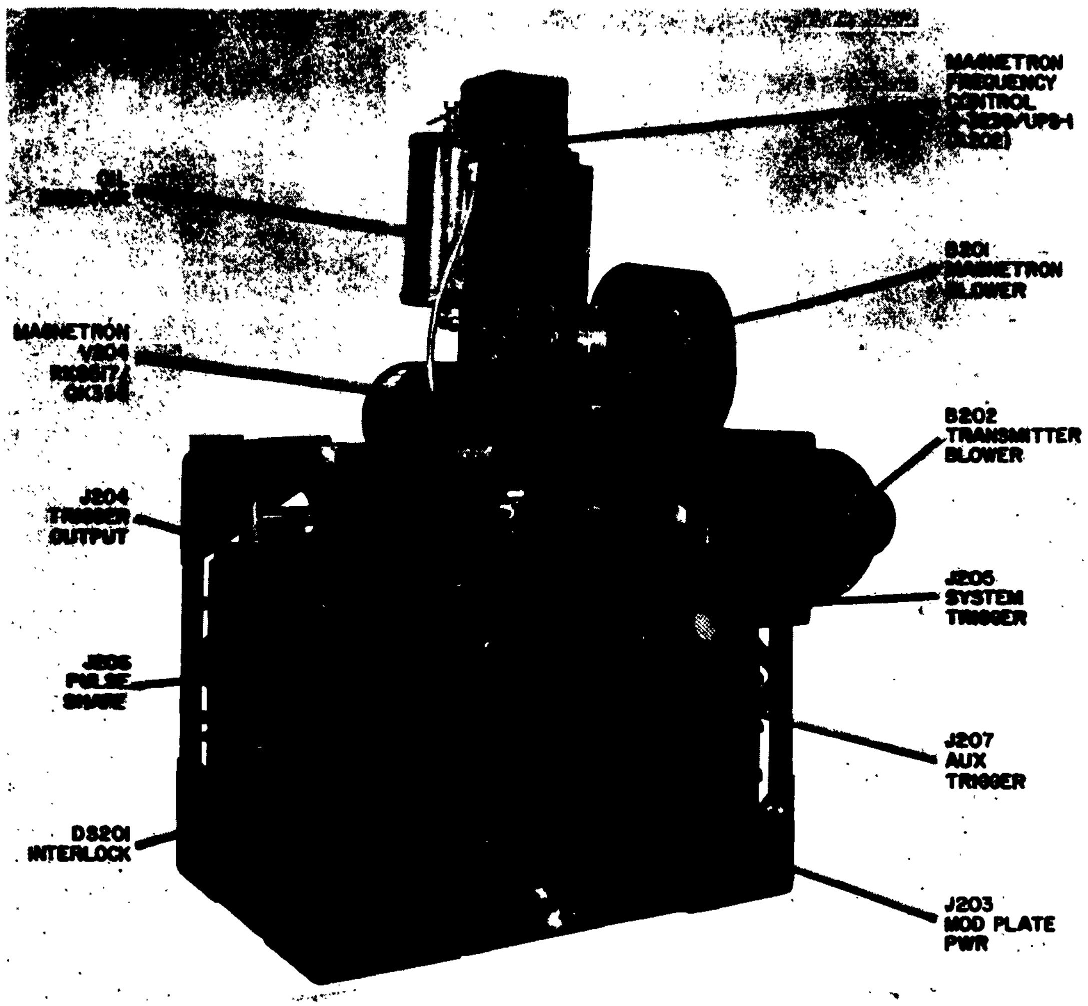


Figure 2-6. Modulator Transmitter Group

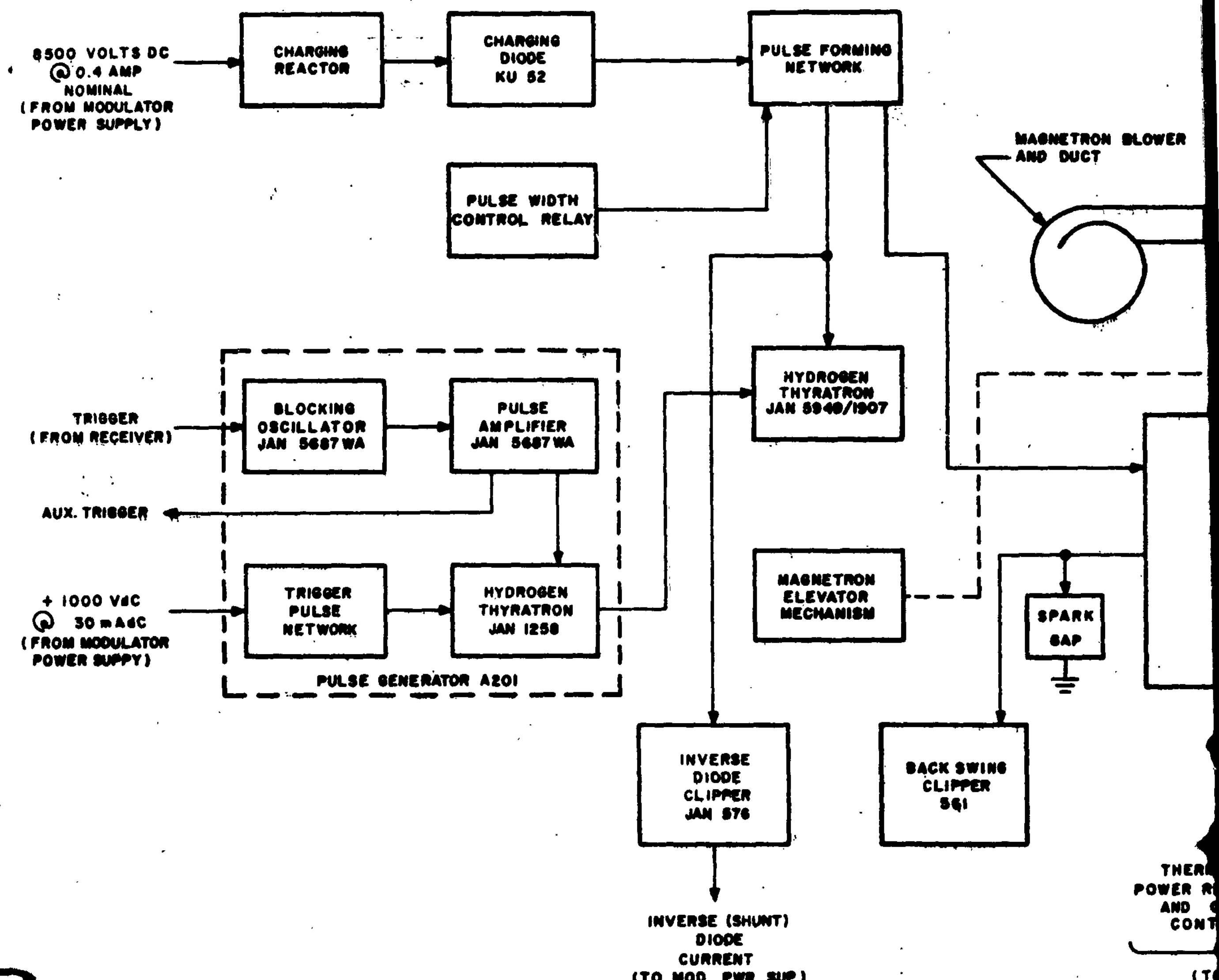


Figure 2-7. Modulator transmitter group, block diagram

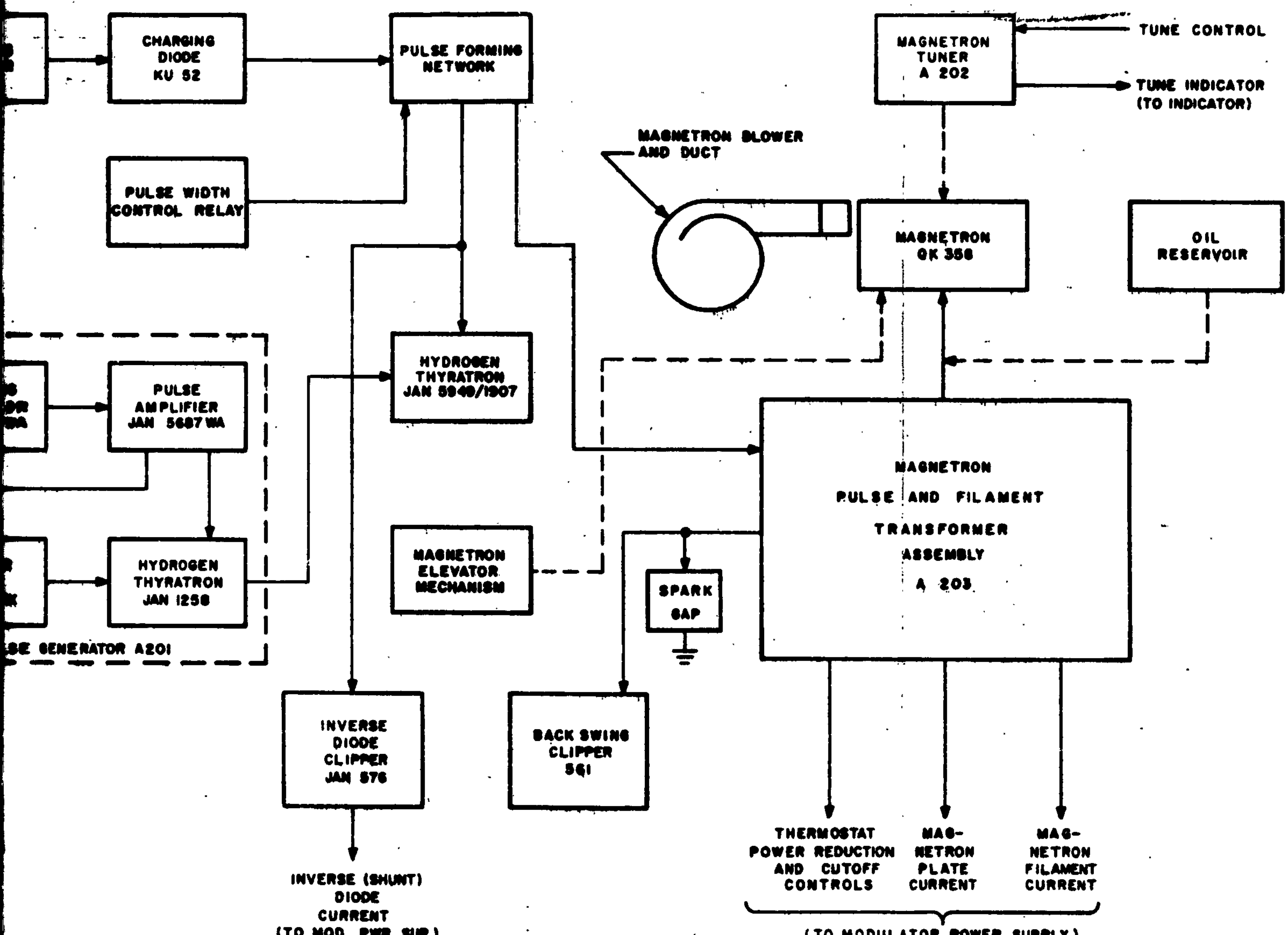


Figure 2-7. Modulator transmitter group, block diagram

The pulse network has an impedance of 25 ohms (±5%). It is basically a 3 mesh network which supplies an output pulse width of 4.2 microseconds (±10%). High voltage contacts on the pulse width control relay disconnect 2 of the 3 meshes when desired, leaving a single mesh in the circuit which will supply an output pulse of 1.4 microseconds (±10%).

The pulse is initiated by a triggering hydrogen thyratron (JAN 5949/1907). The trigger pulse generator which is a removable plug-in chassis, accepts a 30 to 50 volt trigger pulse from the receiver unit. A pulse amplifier triggers a blocking oscillator (1/2 JAN 5687) which drives an isolation amplifier (1/2 JAN 5687), which in turn triggers a miniature hydrogen thyratron (JAN 1258). The miniature hydrogen thyratron discharges the trigger pulse network (a 2 microsecond, 5 mesh, 50 ohm network which has been resistively charged from the +1000 volt dc supply) through a pulse transformer, to drive the grid of the main hydrogen thyratron switch tube.

The main hydrogen thyratron switch tube discharges the stored energy on the pulse forming network into the primary of the magnetron pulse transformer assembly. Nominal value of the primary pulse is 8150 volts at 325 amperes peak (2.65 megawatts peak). The pulse width is either 1.4 or 4.2 microseconds (nominal), depending on the setting of the pulse width control relay. Step-up ratio of the magnetron pulse transformer will be 6.9:1, thus supplying a nominal 56 kv, 47 ampere peak pulse to the cathode of the RK6517/QK358 magnetron. Nominal output power is 1.0 megawatt peak. A 30 kv (nominal) tap is provided on the secondary of the pulse transformer to feed the spark gap and the backswing clipper (type 561). The type 561 diode backswing clipper holds the backswing voltage to less than 15% (of forward voltage), and clamps the backswing rapidly enough to eliminate post pulse noise. A spark gap is provided to protect the pulse transformer and associated circuitry in event of an open circuited load (which could make the

forward voltage peak exceed twice normal). The spark gap is set to break down at forward voltages in the range of 35 kv to 50 kv (at the "nominal 30 kv" tap).

Inverse voltage left on the pulse forming network after the pulse is removed by the inverse clipper (a type JAN 576A). The inverse diode current is filtered and fed to the modulator power supply for monitoring (and to trip out the high voltage if the inverse current becomes excessive due to magnetron arcing).

A series RLC pulse shaping circuit is connected across the pulse transformer secondary. Characteristics of this RLC circuit are such that, when combined with the pulse transformer and pulse forming network parameters, the voltage pulse applied to the RK6517/QK358 magnetron has the proper characteristics to assure complete modulator/magnetron "compatibility" insofar as normal operation is concerned. To achieve the 30 db SCV specification, some magnetron selection may be necessary; however, present data indicates that there will not be any real problem in that the worst magnetron to date provides better than 25 db SCV.

A capacitance divider samples the secondary pulse voltage waveform which may be viewed at either of two BNC jacks on the side of the modulator transmitter case.

Filament voltage is supplied to the magnetron via a low capacitance filament transformer and a surge limiting inductor. The primary filament current is conducted to the modulator power supply for monitoring (and adjustment to the proper valve).

The average magnetron plate current (from the low end of the pulse transformer secondary) is filtered and conducted to the modulator power supply for monitoring.

Two thermostats are mounted in the pulse transformer assembly. A thermostat actuates for oil temperatures above 85°C, causing the power output to cut back to 70% of normal full power. If the oil temperature exceeds 105°C, another thermostat actuates and shuts off high voltage until the equipment cools off.

A tuning unit will be supplied for controlling the magnetron output frequency. This unit is remotely controlled from the Indicator unit, is capable of tuning the range from 1250 to 1350 Mc in less than 100 seconds, and feeds a "position indication" voltage back to the indicator in order to permit setting the operating frequency to a pre-determined value ± 5 Mc.

An oil reservoir will be supplied for keeping the proper oil level around the magnetron cathode bushing. This unit will mount on the shelter wall near the modulator transmitter. Transparent hoses will be used to connect the oil reservoir to the pulse transformer, for easy monitoring of oil level. Quick disconnect fittings will be used to connect the hoses to the pulse transformer.

A centrifugal blower, capable of delivering a minimum of 125 cubic feet per minute of air to the magnetron anode, will be mounted outside the shelter in operating configuration, with suitable ducting between the magnetron inlet, RAOC, sand and dust filters, and rain shield. In transport condition, this blower will be carried inside the shelter. A second centrifugal blower, properly ducted, will provide filtered cooling air to the modulator/transmitter case.

D. Maintainability and Serviceability

This group is easy to service through front and rear access openings. Due to the inherent simplicity of the circuitry in the group, serviceability does not require complex movable chassis. All tubes are

positioned near outside surfaces of the unit for easy access and removal. The magnetron elevator, operated by a removable handcrank, makes the magnetron replacement procedure very easy. The removable pulse generator makes the smaller components within it readily accessible. Fault isolation in the module is facilitated by test points at all salient circuit junctions. A modulator video-pulse high voltage viewing circuit is included, to assist in analyzing modulator malfunctions.

E. Reliability Figure

The reliability figure is 1500 hours, exclusive of magnetron life which is expected to be 500 hours or more.

2.2.4 MODULATOR POWER SUPPLY GROUP

A. General

The principal function of the modulator power supply is to provide plate power for the modulator/transmitter. Auxiliary functions include protection for the modulator/transmitter and the supply. Extensive metering facilities and relay logic for pulse-width switching also are included.

Features include a proportional time delay device which minimizes waiting time in the event of momentary power interruption, but which provides adequate warmup control for the modulator/transmitter main thyratron and magnetron.

The power supply is the same as that employed in the existing production radar, except for a change in the warmup delay relay and deletion of the square tubing transport frame surrounding the case.

A front panel view of the power supply is shown in Figure 2-8. Not shown, but a part of the supply, is a simple but rugged aluminum case containing an inlet air filter and ball-bearing rollout slides.

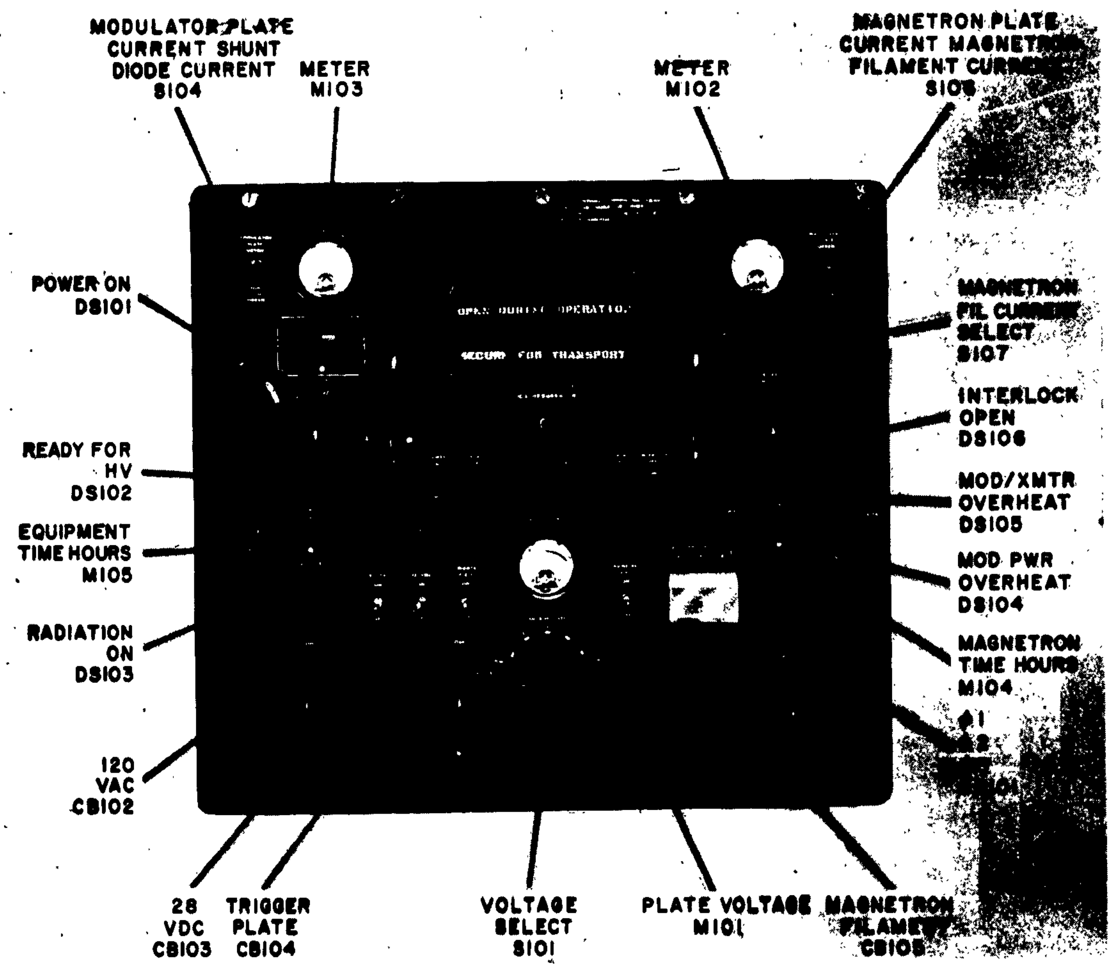


Figure 2-8. Modulator power supply panel layout

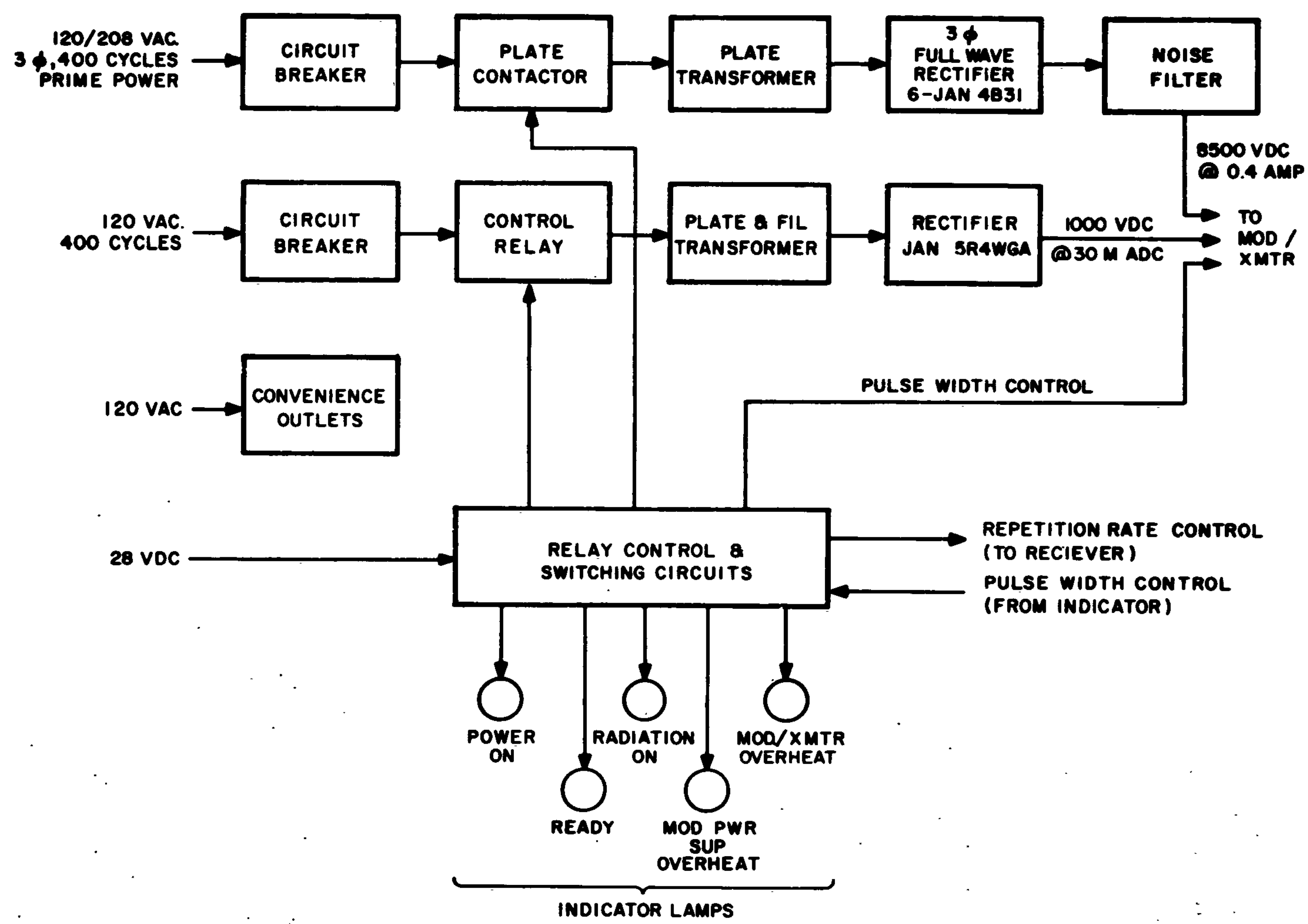


Figure 2-9. Modulator power supply block diagram

B. Overall Block Diagram

Figure 2-9 diagrams the individual functions of the modulator power supply group.

C. Description of Operation

Input power to the modulator power supply will be as follows:

(1) 120/208 volts ac, 400 cycles, 3 phase, at 12 amperes nominal
(2) 120 volts ac, 400 cycles, at 7 amperes nominal.
(3) 120 volts ac (for convenience outlets)
(4) Plus 28 volts dc at 1.5 amperes nominal.

All ac supplies will be ±1% in voltage and ±2% in frequency.

Circuit breakers will be used exclusively for protection of components in the modulator power supply. The following circuit breakers will be provided:

(1) A 15 ampere, 3 phase breaker for the 3 phase power
(2) A 10 ampere breaker for the 120 volt single phase power
(3) A 5 ampere breaker for the 28 volts dc
(4) A 1/2 ampere breaker for the 1000 volt dc supply, and
(5) A 5 ampere breaker for the magnetron filament voltage.

No breaker is provided on this power supply for the convenience outlets. Adequate protection is afforded by a central breaker for all outlets on the radar components.

Suitable time delays and interlocks will be incorporated to assure both personnel and equipment protection. Standard time delay (to allow filaments to warmup) will be 15 minutes (before either the 8500 volt or 1000 volt dc supplies can be energized). In case of power interruptions of 30 seconds or less, an automatic re-cycling device in the time delay

relay will cause a 60 second delay after power is restored. For interruptions from 30 seconds to 15 minutes, the re-cycling time will be proportional to the off-time. For interruptions over 15 minutes, the full 15 minute delay cycle will be repeated.

Thermostats are provided to protect the equipment from overheating. If the temperature in the modulator power supply exceeds 65°C, or if the temperature in the pulse transformer oil exceeds 85°C, the control circuits will automatically cut the power back to 70% of normal full power. If the temperature in the modulator power supply exceeds 85°C, or if the temperature in the pulse transformer oil exceeds 105°C, the high voltage will be automatically cut off until the equipment cools.

An altitude switch is provided to automatically cut power back to the 70% level if the ambient pressure falls below a value corresponding to 7000 feet altitude. (This cutback is to protect the magnetron output from flashover.)

As seen in Figure 2-9, the 3 phase input power is fed via the circuit breaker and a plate contactor to the high voltage plate transformer. Taps on the plate transformer primary allow the operator to set the power output to the desired level. The secondary voltage is rectified by six JAN4B31 high vacuum diodes to supply the high voltage dc output (nominally 8500 volts at 0.4 ampere dc with tap switch provision for outputs of 5950, 7220, 7850, and 9140 volts dc). The high voltage dc output is fed through a noise filter and a type UG-38A/U connector to the modulator/transmitter.

All large vacuum tube filaments (via suitable transformers) are energized by 120 volts ac (single phase) as soon as the equipment is turned on. It is also fed through a 1/2 ampere circuit breaker and a control relay to the primary of the trigger plate transformer. The secondary

voltage of this transformer is rectified in a full wave rectifier (JAN5R4 WGA) which supplies 1000 volts dc (maximum) at 30 milliamperes dc (maximum) to the pulse generator circuits in the modulator/transmitter.

Twenty-eight volts dc at approximately 1.5 amperes is received from the main power supply and used to perform control and switching functions in the modulator power supply and modulator transmitter. The time delay relay prevents high voltage operation until a 15 minute time delay has elapsed by preventing 28 volts dc from reaching the control circuits. By means of a relay logic circuit, the transmitter can be controlled from the indicator unit: Radiation-On Low; Radiation-On High; Radiation-Off; Overload Reset; Wide Pulse/Low Repetition Rate; or Narrow Pulse/High Repetition Rate. Switching from one mode to another is accomplished in a fraction of a second. Five 28-volt indicator lamps on the modulator power supply front panel indicate equipment status as follows: Power On; Ready (for high voltage); Ratiation-On; Modulator Power Supply Overheating; and Modulator/ Transmitter Overheating.

A dc overload relay senses abnormally high load currents (from any cause) and trips out the 8500 volt dc power supply. The circuit can be reset from the indicator front panel after the fault has cleared.

A shunt diode overload relay senses abnormally high shunt diode current caused, for example, by excessive magnetron sparking, and trips out the high voltage supply. This circuit can also be reset from the indicator front panel.

Extensive metering facilities are provided on the modulator power supply front panel. A 0 to 500 milliampere meter monitors either high voltage power supply current or shunt diode average current, selectable by a toggle switch. A 0 to 100 milliampere meter monitors either

magnetron average plate current or magnetron filament current, also selectable by a toggle switch. A three-position tap switch is provided to set the magnetron filament current to the optimum value. A 0 to 15 kv dc voltmeter monitors the level of the high voltage dc output. Two elapsed time meters are provided: one measures total equipment hours; the other measures high voltage (radiation on) hours.

A shorting resistor discharges the high voltage capacitor (via a relay) in less than one second when the equipment is turned off. As a backup bleeder, the high voltage metering circuit will bleed the charge down to less than 100 volts in about 75 seconds. Interlocks are provided on both the modulator power supply and the modulator transmitter to remove the 8500 and 1000 volt potentials whenever the chassis is projecting from the case or an access plate is open.

A cooling blower is provided in the modulator power supply to supply at least 190 cubic feet per minute of cooling air. Sand and dust filtering and splash proofing are provided.

The modulator power supply is packaged so that all components are easily accessible for maintenance.

D. Maintainability and Serviceability

The supply is designed for easy access to all parts. The means of access is via a sliding insulating plate that mounts the full wave-rectifiers. This plate slides back and down to expose all components mounted on the bottom plate of the unit. Two chassis at the sides containing relays, hinge outward to completely expose the chassis interior. Nearly all relays in the unit are plug-in types.

The completeness of metering, circuit protection, and general control and monitoring functions for the modulator/transmitter and the power

supply, and the features already described above, make troubleshooting and correction rapid and easy.

E. Reliability Figure

The reliability figure is 5300 hours.

2.2.5 MAIN POWER SUPPLY GROUP

A. Function

The main power supply group performs the following functions:

(1) Distributes input power (ac) to the modulator power supply, azimuth range indicator, receiver, and antenna pedestal group of the radar set.

(2) Delivers +350 volts dc to the azimuth range indicator, modulator power supply, and receiver group of the radar set.

(3) Delivers 28 volts dc to the modulator power supply, azimuth range indicator, receiver, and magnetron tuning unit groups of the radar set.

(4) Delivers necessary driving power to the antenna drive motor armature from the Electronic Control Amplifier (-105 to +105 volts dc).

B. Elements

The main power supply group consists of the following elements:

(1) Power control circuits
(2) 28-vdc power supply
(3) 350-vdc power supply
(4) Metering circuits
(5) Electronic control amplifier.

Each element is described in more detail below.

350-vdc Supply

(1) Nature: +350 volts dc ±5%

(2) Ripple: 1.0 v max (60-1000 cps)

(3) Current: 0.09 ampere

(4) Destination: Azimuth range indicator, radar receiver, and modulator power supply

28-vdc Supply – This power supply is as follows:

(1) Nature: +28 vdc, +2 -6%

(2) Current requirements: 2.4 amp at 28 vdc

(3) Destination: Modulator power supply, azimuth range indicator, Magnetron tuning unit, and radar receiver.

Electronic Control Amplifier

(1) Signal input; Search condition:
Nature: dc
Magnitude: -13 to +20 vdc variable by Ant. Speed control

(2) Signal input; Searchlite condition:
Nature: dc with superimposed 400 cps ac single phase
Magnitude: ac from 10 to 30 V, peak limited.

(3) Signal source: azimuth range indicator A811

(4) Signal output:
Destination: antenna drivemotor armature
Nature: dc
Magnitude: 0 to ±105 vdc (at 15 rpm antenna rotating speed)

Metering Circuit - A meter located in the front panel permits monitoring of the following voltages:

(1) 120 volts ac 400 cps phase 1 unregulated
(2) 120 volts ac 400 cps phase 2 unregulated
(3) 120 volts ac 400 cps phase 3 unregulated
(4) 120 volts ac 400 cps delayed
(5) +350 volts dc (voltage)
(6) +350 volts dc (current)
(7) +28 volts dc (voltage)
(8) +28 volts dc (current)

Meter is protected from deterioration in the field.

Circuit Breakers: The following circuits are protected by circuit breakers.

(1)	Auxiliary power input	120 vac	15 A
(2)	IFF power outlets	120 vac	5 A
(3)	+28 VDC input	120 vac	4 A
(4)	Delayed 120 vac input	120 vac	5 A

Provision should be incorporated to cut off the 208/120 3ϕ vac input should one phase or more of the external supply fail to operate properly. A voltage and frequency sensory device will trip the main power contractor under abnormal supply conditions.

Indicators are provided to show:

(1) Presence of power to service outlets
(2) Main power each phase.

Indication of tripped circuit breakers is achieved by observation of the handle position. Fuses are not used in the main power supply group.

Cooling: The main power supply is cooled by a blower with a minimum capacity of 60 cubic feet per minute.

Operator Controls:

(1) Antenna control switch enables the application of main power to the antenna control unit.

(2) Meter selector switch is provided to select inputs to the monitoring circuit.

(3) Main power breaker in 208/120 vac input. This is a companion trip breaker which opens all 3 phases if the current in any leg exceeds 30 amperes average. Adequate delay is provided against trip out on peak surge conditions.

Main Power Outputs:

Destination: modulator p. s., antenna pedestal
Nature: Same as input power

Connections - All electrical connections to the main power supply are routed through the shelter wiring and mated through JAN approved watertight connectors.

C. Primary Power Distribution Circuits and Power Supplies

a. General

The power distribution control is centered on the panel of the main power supply. All input circuits are controlled and protected by circuit breakers on the panel. A metering circuit is provided for monitoring the individual power supply assemblies in the main power supply.

b. Power Sources

A turbine-generator supplies primary power of 208 vac, 3-phase, 400 cycles to connector J1161, pins A, B, and C. The main power circuit is protected by the MAIN POWER circuit breaker CB1161, rated at 30 amperes per phase. A 120 vac, 60 cycle, single phase auxiliary generator can be used as a power source for the SERVICE OUTLETS. Auxiliary power is applied to connector J1162, pins A and B, whenever phase 1, 120 vac, 400 cycle power is not desired. OUTLETS POWER switch S1162 is set to the MAIN SOURCE or AUX SOURCE position depending upon what type power is supplied. In the AUX SOURCE position of S1162, SERVICE OUTLETS circuit breaker CB1169, rated at 15 amperes, protects the circuit. In the MAIN SOURCE position of S1162, power supplied to the service outlets is phase 3, 120 vac, 400 cycles. A neutral ground line connects to other units of the radar through the following connectors; J1161, pin D; filter FL1165, terminals 4 and 8; J1167, pins K and J; Filter FL1162, terminal B; and switch S1162, pin 2. IFF OUTLETS are supplied with phase 1, 120 vac, 400 cycle power through IFF OUTLETS circuit breaker CB1164, rated at 5 amperes. Three-phase, 208 vac, 400 cycles is furnished blower B1161, through circuit breaker CB1162, rated at 12 amperes. Three MAIN POWER indicating lamps are provided to indicate power in the three phase circuit. Lamp DS1163 is for phase 1, DS1164 for phase 2, and DS1165 for phase 2. These lamps light any time the main power is supplied to connector J1161. SERVICE OUTLETS POWER ON indicating lamp DS1161 lights when power is applied to the service outlet circuit. Outlet power may come from J1161 or J1162.

The various power supplies that develop the DC voltages required for the operation of the equipment are located in the various chassis. Primary power is distributed to these various units. The operation of the individual power supplies is described in the following paragraphs. Details of the modulator power supply are given in Section 2.2.3

Delay circuitry as described herein contains provision to permit 60-second power interruption without resetting to start normal delay cycle.

c. Main Power Supply

The dc power supply in this unit consists of a 350 vdc power supply; a 28 vdc power supply; a metering circuit; a phase 2, two-minute time-delay relay; and a system standby-operate relay.

The standby-operate relay is energized by the 28 vdc supply after the MAIN POWER circuit breaker is turned ON; provided CONDITION SELECTOR switch S812 on the Azimuth Range Indicator is not in the STANDBY position and the two-minute time-delay relay has cycled for two minutes. When the two-minute delay relay energizes, contacts 7-11 open, turning off the STANDBY lamp located on the Azimuth- Range Indicator. At the same time contacts 1-9 close to prepare a circuit in the Electronic Control Amplifier (A1162), and contacts 4-12 close to turn on the +350 vdc power supply. When the standby operate is energized, time delayed phase 2 power is channeled through contacts 4-12 to the Radar Receiver and the Azimuth-Range Indicator.

The phase 2 delay circuit is activated when the motor winding of standby-operate relay is energized through its normally closed contacts 1-2. Energizing power is 120 vac, phase 2 voltage applied immediately after the Main Power circuit breaker and 28V input circuit breakers are turned ON. After the motor has run for two minutes, it opens its energizing contacts 1-2, to cut itself off and closes contacts 6-8 and 3-5. These contacts are latched closed by clutch coil 9-10 of the standby-operate relay, which is energized by the 28 vdc source during the two-minute running interval of the motor. The clutch coil remains energized keeping the contacts latched as long as the MAIN POWER circuit breaker and the 28 vdc circuit breaker are turned ON. The two-minute delay gives the filament circuits in the various units time to warm up before plate voltage is applied.

d. 28-vdc Power Supply

These circuits are powered from phase 2, 120 vac source, through terminals 3 and 24 of J1081. The AC power is applied to the primary winding of a stepdown transformer whose secondary voltage is applied to a silicon full-wave bridge rectifier. The resultant pulsating dc output is smoothed by a capacitive input filter. The 28 vdc output is taken across series bleeder resistors and channeled-out of the dc power supply through terminals 13 and 21 of J1081.

e. 350-vdc Power Supply

These circuits are powered by the phase 2, 120 vac, delayed power through terminal 4-12 of K1082 and terminal 24 of J1081. This 120 vac is applied to the primary of a step-up transformer whose secondary winding applies power to a silicon full-wave bridge rectifier. The pulsating dc voltage output of the rectifier is smoothed by an inductive input filter. Output of the 350 vdc power supply is taken across a bleeder resistor and channeled through terminals 18 and 22 of J1081. This output is distributed to the modulator power supply, receiver, and indicator. An interlocking circuit is provided by a cabinet interlock switch, circuit breaker and contacts 4-12 of the Standby-operate relay. Unless this relay is energized, the input to the 350 vdc power supply is open and there is no 350 vdc output.

f. Metering Circuit

A meter in conjunction with METER SWITCH S1163 monitors the inputs and outputs of the Amplifier-Power Supply. Monitoring parameters are the 120 vac, 400 cycle, phase 1, 2, and 3; 120 vac, 400 cycle, phase 2 delayed; +350 vdc; +28 vdc; and current in the +350 and +28 vdc circuits. In the first four positions of S1163, the AC VOLTS selections are monitored. Voltages checked are the supply source, phase 1, phase 2, phase 3, the time delayed phase 2; all of which are nominally 120 vac

at 400 cycles. Samplings of these ac voltages are rectified before they are applied to the dc meter M1161. Rectification is by a half-wave rectifier in the dc power supply. AC voltage is fed into the dc power supply through a current limiting resistor and then rectified. Another half wave rectifier keeps the reverse voltage across the rectifier combination near zero. The dc meter voltage is taken across a bleeder network and fed through S1163B to the high side of the meter. The low side of the meter is connected to S1163C which is tied to neutral ground.

In the 28 vdc supply a resistor is inserted between the chassis ground and the low side of the rectified dc output for relative current voltage monitoring. When the panel metering selector is in the 28 V I position, this monitoring circuit is placed into operation. A relative indication of the 28 vdc supply current drain can be checked at any time by the operation of the switch.

Similar current and voltage monitoring provisions are provided for the 350 vdc supply circuits.

g. Electronic Control Amplifier (A1162)

This chassis is located in the main power supply. The circuits consist of a thyratron stage, a magnetic amplifier stage, a demodulator stage and relays used for switching and protection.

The thyratron stage consists of four thyratrons, V901 to V904. An ac voltage is applied across each thyratron, permitting each tube to conduct for a portion of each half cycle. The amount of current each tube supplies to the load is determined by the firing angle of the voltage pulse applied to its grid. This pulse is a sinusoidal function, however, the current in the tube is also dependent upon the speed of the antenna drive motor. The motor generates a back emf that appears

to the tubes as an additional voltage source. In normal operation, the back emf is of such a polarity as to reduce the conducting time of the tube. In the continuous SEARCH mode, the outputs of three thyratrons V902, V903, and V904 are combined at their cathodes to supply the load current. V901 provides dynamic braking under overhauling wind conditions. In the SEARCHLIGHT mode of operation, V902 and V904 rotate the antenna clockwise and V901 and V903 provide current for counterclockwise rotation. K901 and K902 provide a means of switching between modes. A larger filter capacitor C905 reduces the ripple of the pulsed current before it enters the armature of the antenna drive motor. Simple inductors L901A and B, and L902A and B in the plate circuits of the thyratrons limit the peak current to a safe value. The thyratron firing angle, and consequently the average thyratron current, is controlled by a magnetic amplifier. To increase the speed of the antenna motor, the firing angle of the thyratrons is decreased.

The magnetic amplifier Z901 controls the precise firing point of the thyratron tubes. It provides a triggering pulse with a very steep wave front. The phase shift of the leading edge of this voltage pulse with respect to the thyratron plate supply voltage is proportional to the dc current in the magnetic amplifier's control winding. The relationship between input current and output firing angle is non-linear except for a small range of input currents near zero. Four outputs are provided by the magnetic amplifier, one to control each of the four thyratrons. The magnetic amplifier controlling V903 is switched between operational modes to insure the proper phase relation between the magnetic amplifiers and the thyratrons.

Four relays K901 and K904 are used in the Electronic Control Amplifier. Two of these, K901, K902 are function changing relays and the other two, K903, K904 are protective relays. Relays K901 and K902 have their coils energized by 28 vdc when the mode of operation is

switched from continuous SEARCH to SEARCHLIGHT operation. The contacts of K901 switch the supply voltage on V903 from ϕB applied to the plate, to ϕC applied to the cathode. Relay K902 switches the input supply voltage and reverses the direction of current through the control winding of the magnetic amplifier so its output pulse is of the proper polarity and phase to control thyratron V903. K902 also completes a ground connection to the phase-sensitive demodulator circuit in SEARCH-LIGHT operation to keep the demodulator operational. The two protective relays are K903 and K904. K903 is a thermal time delay relay with a two-minute delay. In conjunction with K904, it prevents thyratron tube firing until the filaments of the thyratron are heated. Short circuit protection of the motor field is provided by obtaining the energizing voltage for K904 directly from the motor field terminals. One pole of K904 is used to open the circuit to the heating element of K903 and lock in its own coil. This feature is intended to increase the life of K903 and offer greater protection to the thyratrons recycling after power failure.

The phase-sensitive demodulator circuit consists of transformer T901 and ring demodulator CR909 to CR911. It is a simple attenuator in the normal search mode of operation, but acts a demodulator in the search-light mode of operation. A dc voltage proportional to the positional error is obtained at the input to the magnetic amplifier.

A limit circuit using Zener diodes provides improved antenna control. An initial reference voltage appears at the input of the magnetic amplifier at stall speed. For positive signals into the magnetic amplifier, this reference voltage is determined by the breakdown voltage of Zener diode CR903 and the forward drop of CR904. When a negative signal is driving the magnetic amplifier the Zener breakdown voltage of CR904 and the forward drop of CR903 combine to produce the initial reference voltage. If the reference voltage is exceeded by the signal voltage in

either polarity, the signal voltage will be effectively clamped by the Zener diodes. This limits the firing angle of the thyratrons and the average current in their loads. As the speed of the motor increases, a voltage drop will appear across R903. This raises the level of the reference voltage and permits the signal voltage to the magnetic amplifier to increase. A two slope limiter is necessary to achieve proper regulation of the antenna motor. This is done by another pair of Zener diodes. When the motor reaches approximately half speed, CR901 or CR902 break down, shorting out R903. This changes the slope of the voltage drop across R903 with further increasing speeds, and permits higher currents than would otherwise be possible.

D. Mechanical Description

The Main Power Supply case is submersible in the transport condition. It is 33-1/2 inches high, 23 inches wide, and 28 inches deep; encloses 12 cubic feet, and weighs 170 lbs.

The chassis slides out to the front, revealing the underside of the chassis mounted on each side.

E. Reliability

MTBF 4000 hrs., based on 90 percent confidence level.

2.2.6 ANTENNA PEDESTAL GROUP

A. General

The antenna pedestal should be identical to the type presently employed in a current production model system. The pedestal was designed by RCA, and has been used extensively the the military in the field.

B. Technical Description

The antenna pedestal provides the mechanical support and drive mechanism for the radar antenna. The pedestal contains a rotary waveguide coupler assembly, an IFF coaxial rotary coupler, the drive components, and the drive train gear box. The pedestal consists of cast and welded construction.

To prevent condensation in the rotary coupler, a 500-watt ring heater is furnished inside the turret air chamber. The heating unit will deenergize at approximately 110°F, and will be energized when the temperature drops to 80°F. The drive gears are cooled by forced circulation of oil.

Two 250-watt oil heaters are installed in the gear box to maintain the oil between 25° and 50°F. Waterproof service outlets are supplied on the pedestal. A type 13CX4 synchro is mounted in a 1-to-1 ratio with the antenna. It will be zeroed when the antenna faces forward on the shelter. A drawing of the synchro installation is shown in Figure 2-10.

Two type IR23N4 resolvers will be mounted in 1-to-1 and 10-to-1 ratios with the antenna to supply remote indicators with antenna position information. 426.6-cycle excitation of the resolvers will be furnished from the resolver reference generator and they will be zeroed the same as the synchro. A drawing of the resolver installation is shown in Figure 2-10.

A study conducted by RCA revealed that the addition of two resolvers can be accomplished by the use of an add-on gear box which would extend under the existing gear housing. Except for the downward extension, the envelope of the existing gear box will not be exceeded.

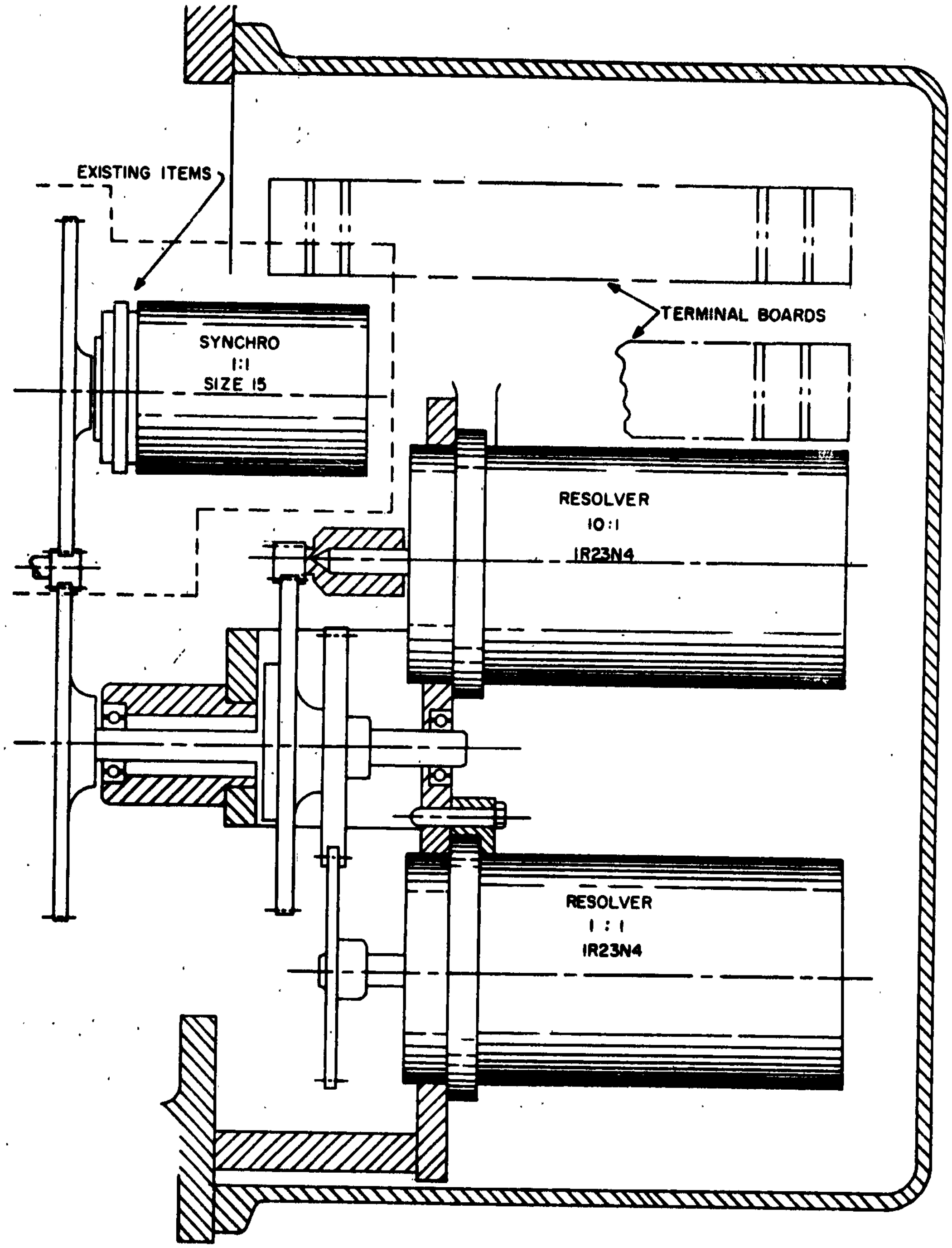


Figure 2-10. Modified data gear box

Depending on the accuracy required, the gear backlash will be controlled by eccentric adjustments on each shaft, or by the use of accurately jig bored plates and dowel pins between assemblies. JAN approved, water-tight connectors will be used throughout, and will be protected against water in accordance with MIL-C-5015.

The pedestal will rotate the reflector about a vertical axis in a clock-wise direction at varying speeds from zero to 15 rpm under no-load conditions under the following tolerances: ±0.5 rpm from zero to 3 rpm, and ±15 percent from 3 to 15 rpm. An antenna speed indicator will be provided with an accuracy of ±0.5 rpm.

When the antenna speed indicator is set at 2.6 ± 0.5 rpm, the antenna will not stall in a 60-knot wind; however, a dial setting of 2.6 ±0.5 rpm will not necessarily indicate the instantaneous antenna speed. The same will apply to the following: the speed indicator set at 1.8 rpm ± 0.5 rpm in a 50-knot wind, and 0.8 rpm ±0.5 rpm in a 40-knot wind.

To indicate when the antenna unit has been brought into true level, spirit level indicators will be supplied to give accurate indications of the pedestal attitude. A blower will be provided on the pedestal to cool the drive motor and waveguide rotary coupler.

The voltage standing wave ratio for the waveguide and IFF rotary couplers will not be greater than the following rates: 1.23 to 1.0 measured through the flexible waveguide for the waveguide coupler, and 1.5 to 1.0 measured through the input jack for the IFF coupler. The IFF rotary coupler will be lubricated externally in accordance with MIL-I-8660. The waveguide will maintain electrical continuity through the rotary joint by utilizing choice couplings; no physical contact will be made.

To hold the antenna at a desired elevation angle, a tilting device will be provided, and it will indicate inclination at 0, -2, and +5 degrees.

Environmental Conditions - When operating, the unit will meet the specified requirements when subjected to a wind of 52 knots from any horizontal direction, and will operate with degraded performance, but without structural damage, in winds between 52 knots and 100 knots. When the unit is non-operative, it will withstand a wind of 100 knots in any horizontal direction without structural damage.

In order to utilize the proven capabilities of the existing production pedestal, antenna, and servo drive, these items should be capable of operation with a maximum of 1/8 inch of rime ice on all external surfaces. Under this icing condition the unit will be capable of operation without any degradation in performance or structural damage.

The unit will also be capable of operation without degradation in performance under conditions of up to two inches per hour of rain or up to one inch of snow per hour. The unit should be tested in accordance to MIL-E-4970 with shelter doors open, and rainfall slanting at a 45-degree angle.

The unit should also be capable of operation without degradation or structural damage under the following conditions: 95 percent humidity, including condensation; atltitudes up to 10,000 feet above sea level; sand and dust atmospheres in accordance with MIL-E-4970; salt atmospheres in accordance with MIL-E-4970; and resist fungus in accordance with MIL-E-4970.

C. Maintainability and Serviceability

The pedestal, with slight modifications, has been designed for easily accessible and trouble-free components; therefore, maintainability and serviceability of the pedestal will meet all requirements.

2.2.7 RESOLVER REFERENCE GENERATOR

A. General

A resolver reference generator (Figure 2-11) supplying a 426.6 cps basic reference frequency should be supplied as part of the AN/TPS-35 Radar Set. The output of this unit supplies a three-wire, quadrature-phased reference for the radar antenna resolver.

Two cathode followers are supplied to provide signal matching from the resolver outputs to the microwave link.

B. Technical Description

The resolver reference voltage is generated by a 426.6 cps oscillator. The frequency will be controlled by a Vibrasender. The vibrasender consists of a tuned cantilever reed made of alloy steel, a coil, and two permanent magnets. The reed is mounted so that one end is free to vibrate within the magnetic influence of the coil. The combination of the vibrating reed in the magnetic field of the coil acts as a high Q resonant circuit. A high order of amplitude and frequency stability is obtained by an AGC voltage, supplied to the grid of the oscillator as described below. The frequency stability of the oscillator will be better than 0.5 percent.

The output of the oscillator is fed to a buffer amplifier which serves to increase the amplitude of the signal, and to isolate the oscillator from the load circuit. The output of this amplifier drives a second amplifier, and also feeds a crystal rectifier. This rectifier, in conjunction with an RC filter network, converts a portion of the 426.6 cps signal to a dc voltage that is proportional to the amplitude of the 426.6 cps signal. This dc voltage is fed back to the grid of the oscillator tube. By controlling the amplitude of the oscillator output external to the oscillator

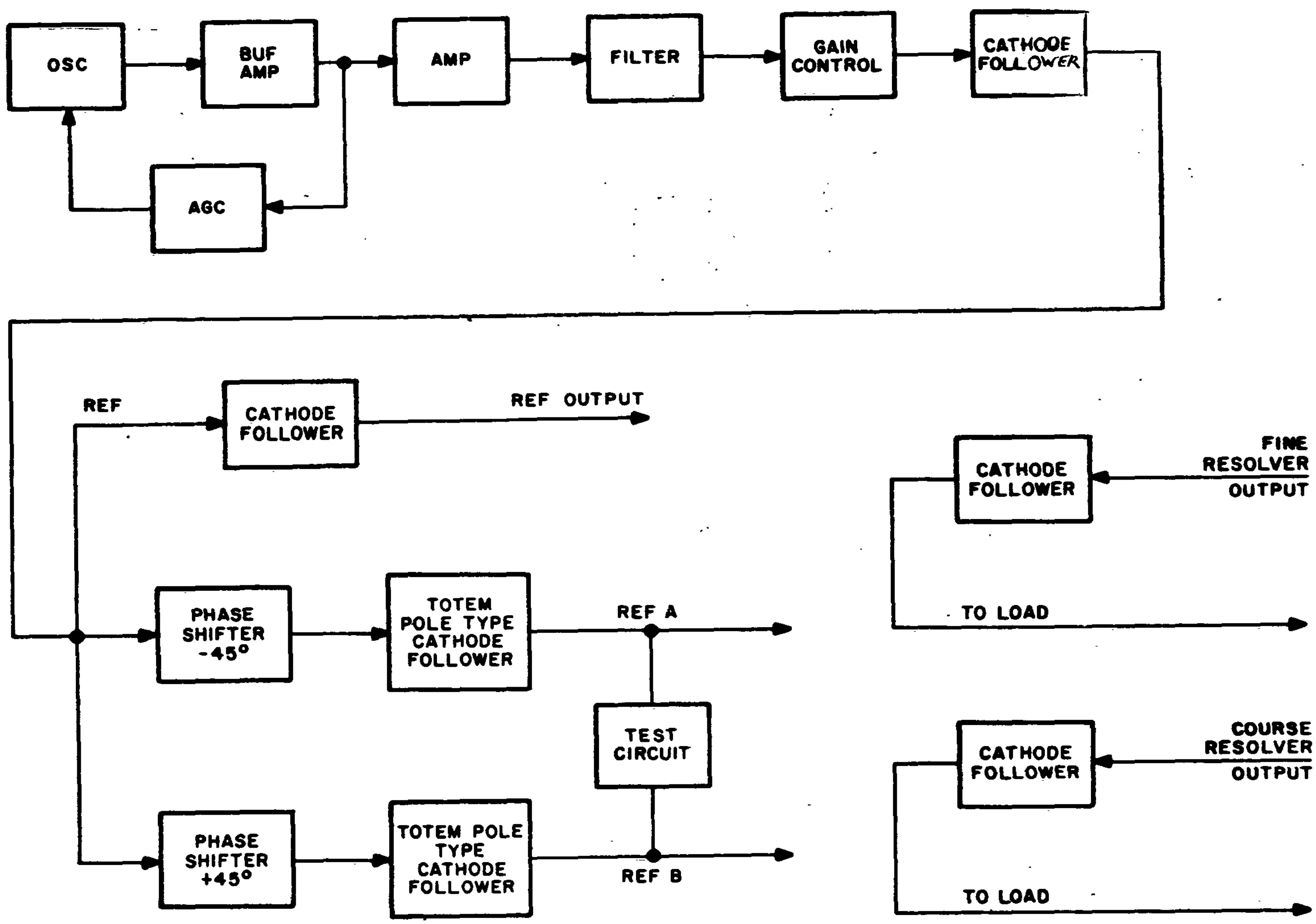


Figure 2-11. Overall block diagram

tube itself, the signal distortion is reduced, and the additional open-loop gain provided by the amplifier stage improves the amplitude stability of the oscillator. The output of this amplifier stage also drives a second amplifier as mentioned above, and the output of this second amplifier feeds a filter which reduces the harmonic distortion of the signal to less than 0.5 percent.

The output of the filter feeds a cathode follower through a gain control to provide adjustment of output voltage. At the output of the cathode follower, the signal splits into three parts: the first output is the reference output which is unchanged in phase; the second output, Ref. A, is retarded in phase 45° from the reference output by an RC network. The load is coupled to the phase-shift network by means of a totem-pole type cathode follower. This type of circuit provides a source impedance of approximately 10 ohms. The third output, Ref. B, is advanced in phase 45° from the reference output by means of an RC network. This output is coupled to the load by means of a totem-pole type cathode-follower similar to that used for Ref. A. We thus have three outputs: a reference output, and two outputs leading and lagging the reference output by 45°. These latter two outputs are thus 90° out of phase with respect to each other. These latter two outputs are fed to the resolver stator quadrature fields.

The harmonic distortion at the output of the filter will be less than 0.5 percent. Since a properly designed cathode follower generates negligible distortion, the harmonic distortion of the three outputs will also be less than 0.5 percent.

A test circuit is also provided, which (in conjunction with a cathode-ray oscilloscope) is used to check the 90° phase difference between Ref. A and Ref. B.

In addition to providing the outputs described above, two cathode followers will be incorporated to couple the fine and coarse resolver outputs to the microwave system. The output voltage of each of these cathode followers will be at least 0.5 volts rms.

All of the above outputs, Ref., Ref. A, Ref. B, and the fine and coarse resolver outputs, will be made available to the input of the cable connector at the junction box for cable remoting purposes as well as to the microwave system.

The relative amplitude of the reference and rotor signals will be well within ten percent at the end of the remote cable, provided that the wires carrying these signals are approximately equal in size and length.

C. Mechanical Discussion

The resolver reference generator will be an integral part of the Radar-Microwave Junction Box. The reference generator will be chassis mounted and capable of being removed from the junction box for major servicing.

Shock mounting should be employed, if required, to obtain the desired frequency stability.

D. Maintainability and Serviceability

The unit, as mentioned, is removable from the junction box to provide ease of maintenance and replaceability. All power and signal inputs should be applied through connectors. Suitable test points are provided to monitor all output signals and monitor pertinent points for testing and calibration purposes.

E. Reliability

The MTBF figure for the Resolver Reference Generator, is ≈ 4000 hours.

2.2.8 ANTENNA GROUP

A. General

The AN/TPS-35 radar antenna is a modified parabolic screen reflector providing a cosecant-squared radiating pattern in elevation. The antenna assembly consists of a reflector, sectoral feedhorn and associated feed, a hybrid switch to provide polarisation diversification, an IFF horn, and the associated supporting hardware.

B. Technical Description

The antenna reflector is a modified parabolic screen with a horisontal aperture of approximately 15 feet 9 inches and a vertical aperture of 6 feet 2 inches.

The electrical characteristics of the antenna are as follows:

(1)	Horisontal Beamwidth:	3.7° $<5.0^{\circ}$ up to 40° elevation
(2)	Main Beam Elevation:	3.0° (0° antenna elevation)
(3)	Vertical Beamwidth:	$\approx 11.0^{\circ}$
(4)	Cosecant Squared Response:	Nominally between 9° and 36°
(5)	Antenna Gain:	≈ 26 DB over 1250 - 1350 mcps
(6)	Sidelobe Levels:	≈ -26 DB from maximum radiation ($\pm 5^{\circ}$ elevation)

(The preceding characteristics are applicable over the range of 1250 - 1350 Mc)

a. Polarization Diversification

In considering the conversion of the Type II antenna from its present form to a capability of selectable linear or circular polarization, several objectives must be taken into account. Each objective has design problems associated with it. The objectives are discussed individually in this section. The latter part of this section summarizes the conclusions reached, and outline the approach to the antenna-feed design.

1. Performance objectives - It is intended that the rapid tunability feature of the basic equipment be preserved. This means that the feed system derived must have the capability of providing rain clutter cancellation over the operating 1250 to 1350 Mc frequency band without adjustment.

It is desired that a 1 db axial ratio be maintained in order to achieve an integrated cancellation ratio of approximately 20 db. As will be indicated in more detail later, it is expected that this axial ratio can only be maintained within the 3 db points of the antenna pattern in either the azimuth or elevation planes. It is expected that the cancellation ratio will drop to 10 db in the higher coverage area of the csc^2 pattern.

A further objective is to preserve, as nearly as possible, the present high angle coverage characteristics of the Type II antenna when switched to the linearly polarized condition.

The power handling capability of 1.4 megawatts peak, 2 kw average at 10,000 ft altitude must be preserved.

The added size, weight, and complexity must be kept at an absolute minimum in order to maintain a low moment of inertia for the antenna and a maximum transport and erection capability.

The antenna polarization characteristics are to be remotely controlled with a switchover time of approximately one second. The antenna is to provide an integrated IFF capability.

2. Configuration - Referring to Figure 2-12 it will be noted that the system, to accomplish the switchable polarization, consists of an arrangement very similar to that used on the Type I antenna, but includes also a modified side-wall hybrid and a coaxial connection to a dual mode transition at the horn input.

The hybrid junction, to be discussed in more detail later, also performs the switching function such that in one position, the auxiliary arm is cut off and horizontally polarized operation is obtained. In the other condition, the hybrid provides the necessary equal power split between the orthogonal components feeding the dual mode transition, as well as the 90° time phase required for circular polarization.

As indicated later, the coaxial link is so designed as to compensate the waveguide and horn dispersion characteristics to maintain the objective of 1 db axial ratio tolerance of circular radiation.

Shown in the figure is one of two possible approaches for IFF integration. The method shown employs the vertical mode transition of the search function and the IFF is introduced via a filter-plexing arrangement which isolates the IFF transmitter-receiver from the search system.

Of the many methods examined to solve this conversion problem, the configuration shown is the smallest and lightest, and has at least as good a potential for electrical performance as the others considered. Techniques which were considered included multiple horns, other switching arrangements, turnstile waveguide junctions, etc.

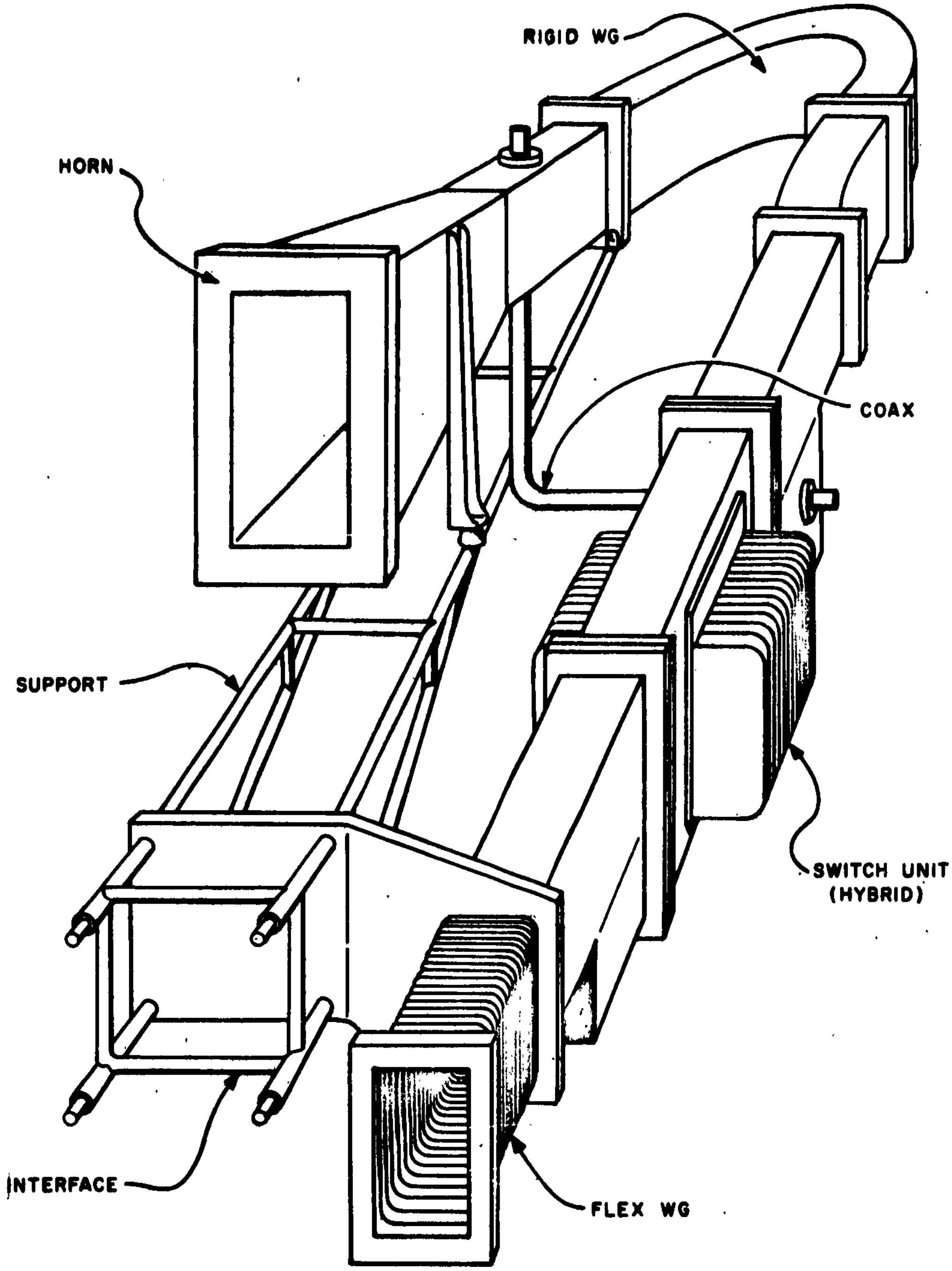


Figure 2-12. AN/TPS-35 circular polarization feedhorn

The following paragraphs deal with each component in detail.

b. Horn Design Considerations

Because it is recognized that the elevation coverage pattern of the Type II antenna is a function of many second order effects which were of necessity derived empirically, it is suggested that the basic horn aperture remain as it is for the horizontally polarized component. It is suggested, however, to change from the present hog horn configuration to a sectoral horn in order to accommodate the bipolarized radiation when required. The IFF dipole (now placed in the horn opening) should be removed, since under the bi-polarized condition it will couple directly to the vertical component. The method of handling the IFF injection is detailed in a later paragraph.

The input to this sectoral horn will include a dual mode transistion, hence will be square. The horizontal component will be a waveguide input arranged in much the same manner as the present Type I antenna. The vertical component will be coaxial employing standard 1-5/8 inch air dielectric line.

In order to obtain the tight axial ratio of 1 db on circularity, it is necessary that the two orthogonal components illuminate the reflector with nearly equal functions. A simple sectoral horn will not do this without modification. It is suggested that the primary illumination be equalized by the use of fins, both azimuth and elevation. A 25 percent correction is required in the elevation plane, and an 8 percent correction is required in azimuth. The fins inside the horn aperture at the top and bottom will, therefore, be approximately 2 inches high, those at either side will be approximately 3/8 inch high.

A horn which is not square (or round) is electrically longer for one of the orthogonal components than the other. Furthermore, because λ_g is

not a linear function with λ_o there is dispersion over the operating frequency band. For the configuration proposed, the difference in path lengths is approximately 97^{o} at 1250 Mc, and 121^{o} at 1350 Mc, showing that a correction of 24^{o} must be accomplished for proper phase tracking. This compensation will be designed into the coaxial link connecting the hybrid junction to the dual mode transducer.

c. Coaxial Feed Line for Vertical Component

In the interest of minimizing added weight on the feed complex, it is recommended that 1-5/8-inch air dielectric coaxial line be used to link the vertical component of the orthogonal pair from the hybrid-switch to the dual mode horn input.

Because this link operates at half the transmitter power only, the maximum voltage gradient experienced in the line is 8.65 kv/cm, compared to a maximum theoretical of 30.0 kv/cm at sea level. At 10,000 feet altitude, the theoretical maximum drops to approximately $30/\sqrt{2}$ kv/cm or 21.2 kv/cm. The selection of 1-5/8-inch coaxial size should, therefore, provide ample safety factor from a breakdown point of view. Average power capability is likewise ample. The peak power computations assume unity VSWR; however, this must be controlled to values of around 1.1 (5% increase) if the phase control required to meet the circular polarization tolerances are held.

The crucial question regarding the arrangement for feeding the horn involves the relative phase and amplitude control which can be maintained between the waveguide and coaxial paths which generate the orthogonal components. A 1 db axial ratio requires that a maximum phase error of 8^{o} be held over the frequency band assuming perfect amplitude split.

As mentioned earlier, the horn introduces a phase slope difference over the band of approximately 24^{o}. The waveguide path length change is

approximately 195° over the 8 percent band. The total phase slope to be incorporated into the coaxial link is the sum of these, thus fixing its length at around 5 feet. The non-linearity of phase slope in the wave-guide section amounts to some 3.5° total over the band, hence this ±1.75° tolerance is not compensated. However, since this is a small number, it will be accepted as a fixed system error.

The success of the design will be dependent upon the degree to which differential reactive mismatches can be controlled. A VSWR of 1.2 can provide as much as 7° electrical length error, hence each of the several junctions involved in either path of the orthogonal components must receive careful design attention. Though difficult, it is believed that the necessary control can be obtained in practice.

Regarding the amplitude balance necessary for good circularity of radiation, there are two major contributors to error. The hybrid balance will have to be maintained at 3 db ±0.1 over this band. Based on past experience of measurements made on side-wall couplers at various frequency bands, such a tolerance is readily achievable. The other contributor is the coaxial link loss as compared to the waveguide path. This difference is calculated to be 0.04 db. Combining these amplitude error factors, a 0.24 db axial ratio would be indicated. This is not considered an excessive contribution.

d. Hybrid - Switch

Development in other frequency bands has produced a combination hybrid-switch which operates by closing the coupling area with four inductive posts. With the posts inserted across the opening, a 20 db isolation of the auxiliary arm is obtained. Withdrawing the posts returns the hybrid to its normal function.

This technique is attractive for this application, since much size and weight are saved over more conventional techniques such as polarization twisters with vertibrae sections, or the moving of shorting plates of turnstile junctions. For the power levels involved here, the posts will move in RF choke sections to minimize driving power and provide best reliability.

e. Integrated IFF Capability

Since it is no longer feasible to place an IFF dipole in the horn because of the direct coupling to the vertical search component, several other techniques were analyzed, with the conclusion that the vertical polarization transducer of the basic search feed must also serve the IFF needs.

Placing dipole arrays at either side of the search horn gives excessive spacing between the dipole elements and results in a gain reduction of approximately 6 db on axis with a considerably widened azimuth beam. In effect, the IFF beam is split. This occurs even with small, heavily loaded horns in a configuration such as that used on BMEWS and TRADEX tracking radar feeds.

If the IFF injection were made in the fourth port of the power dividing hybrid, satisfactory operation and good isolation would be achieved, except that when the radar is set up for circular polarization, a 3 db gain reduction would be expected. If this 3 db loss could be tolerated, this would be the preferred approach.

The last alternative is to inject the IFF through high power low pass filters directly into the search coaxial line link. The problem here is one of designing a filter which will handle the search power without breakdown. This is believed feasible, but adds more weight than the method described above. There would be no degradation in antenna gain. It is this method that is pictured in Figure 2-12.

f. Axial Ratio VS Elevation Coverage Angle

As stated earlier, it is not anticipated that the horizontally polarized coverage will change appreciably from that currently provided by the Type II AN/UPS-1 antenna. Such is not the case with the vertical component when the antenna is set up for circular polarization.

Because the fixed lines radiated from a horn lie on the surface of a sphere and coverage at the poles of that sphere, polarization lines which are orthogonal on the horn axis depart from this condition significantly as a function of the off-axis angle. Now, since the high angle coverage of the antenna is furnished largely by a distorted portion of the reflector near its bottom edge where the polarizations are no longer perpendicular, it does not appear feasible to expect 1 db axial ratio in both the long range portion of the beam and at the high coverage angles. Since it is planned to optimize this circularity for the long range, lower coverage angles, it is anticipated that the integrated cancellation will drop to around 10 db outside the -3 db points of the beam. Such performance has been verified experimentally on other full coverage (csc^2) antennas which were equipped to provide circular polarization.

Because of the relatively small size of the vertical antenna aperture (in terms of wavelengths), it is not believed feasible to quantitatively derive an accurate prediction of the high angle axial ratio analytically.

C. Mechanical Discussion

The antenna reflector is comprised of three (3) sections (center and two tips), and is constructed from extruded aluminum to obtain light weight. Tubular construction is provided for antenna reflection support and rigidity.

a. Feed Horn

(1) The feed horn and associated waveguide, as shown in Figure 2-12 should be fabricated from rigid, L-band, aluminum waveguide. The interface waveguide will consist of a flexible section.

(2) For conversion to circular polarization capabilities, a run of rigid 1-5/8 inch coax and filter should be utilized.

b. Feed Horn Support

The feed horn support should consist of a tubular aluminum welded frame similar to that shown in Figure 2-12. The four-stud interface connection will be compatible to the production pedestal.

c. Combined Weight

The feed horn and feed horn support should be light weight, about 60 lbs, and increase the antenna's inertia about the azimuth axis by approximately 10 percent. This increase in inertia will not affect the system servo. The servo amplifiers are sufficient to handle the increased inertia.

d. Switch Unit (Hybrid)

The switch unit, located on the feed horn, should be used to produce the circular polarization capability. The unit consists of a series of chokes and remotely controlled retractible rods. The retracting rods would be actuated by means of a worm drive and small electric motor. The switch unit could be located as shown in Figure 2-12.

D. Maintainability and Serviceability

The antenna reflector surface may be dismounted into three sections, the center section and two tip sections. The horn and feed assembly is stud-mounted to the rotating portion of the antenna pedestal, thus providing ease in dismounting. An IFF and radar rotating joint is also provided in the pedestal for RF transmission.

E. Carrying Cases

For C130A aircraft transport condition, the antenna will be carried in two lightweight tubular structures.

The reflector tip sections could be stowed in a modified existing type II tower. The approximate case size with stowed tips would be 92 by 68 by 68 inches. The type II tower could be stripped of all unnecessary mechanical features such as shock mounts, blower motors, guides for electronic boxes, and hardware not required for tip stowage. The towers should be altered to permit fork lift handling of the unit. Approximate shipping weight would be 42 pounds per tip section and 140 pounds per case for a total of 224 pounds.

The antenna center section, antenna support, feed horn assembly, and miscellaneous hardware could be stowed in a modified existing type R-F case. The approximate case size, fully equipped, would be 80 by 60 by 58 inches with an estimated weight of 280 pounds. The R-F case also should be modified to permit fork lift handling of the unit.

Overall dimensions of the cases are within the space limits established for truck transport, C130A transport mode, and for mounting on the specified pallet (436L cargo handling).

2.3 CALCULATION OF EXPECTED PERFORMANCE

2.3.1 FUNCTION

The function of the radar portion of the AN/TPS-35 is to provide two-dimensional, aircraft present position data on small cross-section aircraft at ranges normally up to 80 nautical miles with provision for data upon command up to 275 nautical miles. This must be accomplished in search mode in the presence of weather clutter and friendly and enemy

interference. In addition, the radar must operate in confined quarters, compatibly with IFF/SIF and miscellaneous communications equipment. These functions must be achieved by an equipment which is light in weight, long in mission availability time and easily maintained. It must also, in spite of the confined quarters, contribute to an operator environment which encourages his continuing efficiency. This environment is especially important for those missions where the AN/TPS-35 might be separately deployed in an emergency situation. Normally, the AN/TPS-35 must provide its data via microwave link or land line, and under remote control, to the RAPCON of the AN/TSQ-47.

2.3.2 SUMMARY OF RADAR PARAMETERS

The important parameters of the radar required to perform the above function are listed in Table 2-2.

Table 2-2.
Important Parameters of Surveillance Radar

Frequency	1250 to 1350 Mc
Antenna gain	27 db
Antenna Horizontal Beam width	3.7°
Antenna vertical beam shape	Closely csc^2 to 36° and approximately to 42°
Antenna horizontal side lobes	25 db down
Radiated polarization	Horizontal or circular at operator's option
RF power output, peak	1 megawatt
PRF/pulse width	800 pps/1.4 μsec or 267 pps/4.2 μsec at operator's option
System noise figure	3.5 db max. (with paramp) 9.0 db max. (crystal backup)
Receiver bandwidth	1.0 Mc (short-range mode) 330 kc (long-range mode)
MTI performance	30 db SCV
Antenna scan rate	0 to 15 rpm or servo'd searchlight
Displays	10-inch PPI and 3-inch A scope

2.3.3 PERFORMANCE ENVELOPE

The production radar components forming the core of the recommended radar has undergone flight tests of sufficient extent to confirm its predicted coverage performance. Additionally, the tests have demonstrated capability to meet the stringent coverage specifications on the AN/TPS-35. Figure 2-13 is a reproduction of measured coverage performance upon which is super-imposed a dashed line describing the coverage that is expected of the AN/TPS-35 at a typical site. Table 2-3 and the text following it are presented to enable comparison between predicted (calculated) and measured maximum range performance.

Calculation of range performance is detailed in Table 2-3. The method used is that of L. V. Blake as set forth in NRL Memorandum Report No. 1106 with the following modifications:

(a) Collapsing loss was calculated from Hall's article in Proc. IRE, February 1956, using 1 mil spot diameter and 10-inch PPI.

(b) Conversion to 0.9 detection probability was estimated from Hall's article, using false alarm probability equals 10-10.

(c) Number of hits per beamwidth (N) are

$$N = \frac{\theta h \overline{PRF}}{6 \cos \theta \text{ rpm}}$$

where

θ h = horizontal antenna beamwidth = 3.7^{o}

PRF = 267 pps

Cos θ = where θ = target elevation
= 0.99

rpm = antenna azimuth scan rate
= 6 rpm

$$N = \frac{3.7 \times 267}{6 \times 6} = 27.4 \text{ hits.}$$

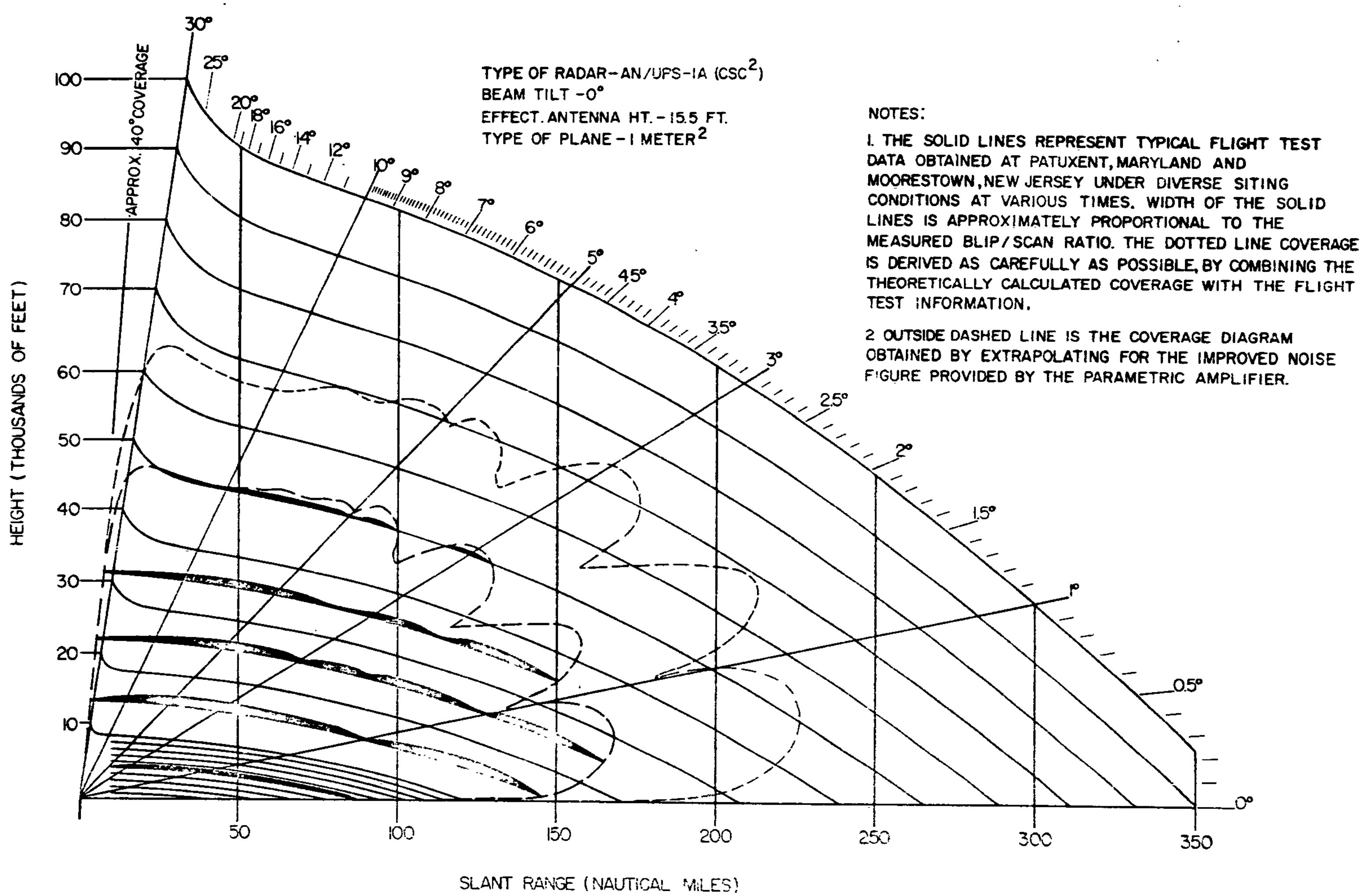


Figure 2-13. Coverage diagram for AN/TPS-35 with CO secant squared antenna

2.3.4 RECEIVER

Receiver bandwidth correction factor is

$$\tau = 4.2\ \mu sec$$

$$B = 0.33 \times 10^6\ cps$$

$$B\tau = 1.4$$

$$C_B = \frac{B\tau}{4.8}\left(1 + \frac{1.2}{B\tau}\right)^2$$

$$= \frac{1.4}{4.8}\left(1 + \frac{1.2}{1.4}\right)^2$$

$$= 1$$

Table 2-3. TPS-35 radar range calibration

Antenna Height = 15 feet

Target Elevation Angle = 1.0^o

		+ DB	- DB
Pt (KW)	= 1000	30.0	
τ (μsec)	= 4.2 μsec	6.2	
Gt	= 27 DB	27.0	
Gr	= 27 DB	27.0	
σ_{50}	= 1 square meter	0.0	
f_{mc}	= 1300 Mc		62.3
T_n	= 500^oK		27.0
$V_o(50)$	= 27 hits		1.4
C_B	= 1	-	-
Lt	= 0.25 DB		0.25
Lr	= 0.3 DB		0.3
Lp	= 1.6 DB		1.6
Lo	= 3.0 DB		3.0

Range Equation Constant		4.45	
Ta	= 130^{o} for antenna elevation	94.65 Sub-Totals	-95.85 +94.65
Lr	= 0.300 (0.933 for 1/Lr)	0.90 probability of detection correction factor	- 1.20 - 1.00 - 2.20
1/Lr	= 0.933		
NF_{DB}	= 3.5 DB		
Tt	= $290^{o}K$	R_2 = 88.1 naut. miles	
T_e/Lr	= $121^{o}K$	Pattern propagation factor = 1.0	
Tr	= $19.3^{o}K$	Le = Atmospheric Absorbtion loss 1.2 DB = 0.933	
Te	= $(\overline{NF}-1)$ To = (2.24-1) 290 = $360^{o}K$	Ro = 88.1 naut miles x 0.933 = 82.2 naut miles	
Tn	= Te/Lr+Tr+Te = $121^{o}+19.3^{o}+360^{o}$ = $500^{o}K$		

The predicted range of 82.2 miles at the bottom of Table 2-3 decreases to 73.7 miles when the 1.4 µsec pulse width mode is recalculated. Since no pattern propagation correction was used in the table to account for ground reflections, these figures are the "free space" range on a one square meter target. If we were to assume perfect surface reflection, the above figures would become approximately double, or 165 and 150 miles respectively.

It is evident from a comparison that measured performance considerably exceeds calculated performance. The principle factor in this apparent discrepancy is that the frequency, antenna elevation beamwidth, and antenna height combine to provide ground lobing. Much of the flight test data was taken over water, where measured radar coverage would be close to double that calculated on the "free-space" basis. Other factors which probably introduce discrepancy between the measured and calculated range performance include:

(a) Target size - There is no assurance that the aircraft used for test (although they were all small fighter aircraft types) were one square meter targets. In fact, there is reason to believe they are larger at this frequency.

(b) Antenna gain, receiver sensitivity, and transmitter power output - In all these parameters the performance of the radar exceeded the nominal values used in the calculation. In total, actual performance of these units probably exceeded the values in the calculation by 3 to 4 db (one way) at the particular frequency in use.

Although it is difficult to identify with precision all of the factors which explain the discrepancy, it is safe to say that the measured performance is typical of what can be expected on century-series aircraft, since these data were taken over a considerable time with a variety of aircraft.

2.3.5 The minimum discernible signal requirement. Measurements on development models of the parametric amplifier have consistently demonstrated MDS of 111 dbm or better. When one consideres the operator factor for MDS measurements is about ±2 db, this is in good agreement with the following calculated value:

A. Calculation of Minimum Discernible Signal (M.D.S.)

Thermal Noise = KTB

K = Boltzinan's constant = 1.38×10^{-23}

T = Degrees Kelvin = 290°

B_n = equivalent system noise bandwidth

The noise bandwidth of a receiver system differs from the measured 3 DB bandwidth by a factor that is dependent upon the shape of the

bandwidth determining network or filter. The factor varies from 1.57 times the 3 DB bandwidth for a simple synchronously-tuned circuit to 1.0 for a true rectangular filter. The band pass filters in the TPS-35 radar have a factor of 1.1 for the wide band (1.0 Mc) filter and 1.22 for the narrow band filter (0.33 Mc).

For narrow band (long range) operation, the MDS is calculated:

(Narrow-Band - Long Range)

$$KTB_n = \frac{1.38 \times 10^{-23} \times 290 \times 0.33 \times 10^{6} \times 1.22}{10^{-3}}$$

$$= 1.61 \times 10^{-12} \text{ milliwatts}$$

$$= 117.8 \text{ DBM}$$

Noise Figure = 3.5 DB

(with parametric amplifier) = -117.8 + 3.5
= -114.3 DBM.

In the required backup mode, where the parametric amplifier is by-passed by an L-band mixer the MDS is calculated:

Noise Figure = 9.0 DB
MDS (no parametric amplifier) = -114.3 DBM + 9.0 DB
= -108.8 DBM.

By similar calculations the MDS figures in the wide band mode (short range) are

With parametric amplifier - 110 dbm
With L-band mixer - 104.5 dbm

The azimuth accuracy of the recommended radar will be within plus or minus one degree. The major factors contributing to the azimuth error of the proposed design are

(a) Pedestal resolver error
(b) Resolution error.

Factor (a) is very small (nominally 0.3°) at 10:1 speed and factor (b) is typically one tenth the azimuth resolution element (azimuth beam-width = 3.7 ± 0.3), or $\frac{3.7 \pm 0.3}{10} = 0.34$ to 0.41°. Thus, the azimuth accuracy, is nominally complied with.

SECTION 3

MICROWAVE REMOTING SYSTEM

The contractor was given the responsibility for determining the requirements for remoting the functions of the search radar and the precision approach radar (PAR) by separate microwave links to the IFR control center. It was first necessary to determine the signals to be remoted and the performance requirements for remoting the signals. This was accomplished and reported in a previous report (AFCRL 500); however, additional signals have been added and the performance requirements are listed again. In order to avoid confusion, the microwave link between the search radar and the IFR control center is referred to as the IFR-search radar link, and the microwave link between the precision approach radar (PAR) and the IFR control center is referred to as the IFR-PAR microwave link. A microwave link is understood to mean the transmission and reception of one or more microwave channels in each direction between the control center and the respective radar.

3.1 REMOTING REQUIREMENTS

The remoting requirements of the IFR-search microwave link are listed in Table 3-1, and the remoting requirements of the IFR-PAR microwave link are listed in Table 3-2. Transmission from the radar set to the IFR control center is listed in Section A of each table, and transmission from the control center to the radar is listed in Section B of each table. The maximum required radio line of sight separation for the microwave terminals of each link is 15 miles for the IFR-Search link and 5 miles for the IFR-PAR link.

Table 3-1. Requirements of IFR-search microwave link

A. Transmission From Search Radar to IFR Center

Signal Designation	Signal Characteristics	Input at Search Terminal	Output at IFR-Search Terminal
(1) Normal Video	Level	2.0 volts peak max	3 volts peak max (adjustable)
	Gain		Gain: Zero ± 1.5 db for input levels from 0.1 to 1.5 volts peak
	Impedance	Source: 75 ohms	Load: 75 ohms
	Polarity	Positive	Positive
	Rise Time	0.6 μsec max	Not more than 0.7 μsec max for input rise time of 0.6 μsec
	Overshoot	Assume none, as reference	Less than 10% for a pulse having a rise time of 0.3 μsec
	Droop	Assume none, as reference	Less than 10% for a 1000 μsec pulse at 250 cps
	Jitter a. Time	Assume none, as reference	Not more than 0.02 μsec
	b. Amplitude	Assume none, as reference	Less than 1 db
(2) MTI (special) video		The requirements of the MTI (Special) video signal are the same as the normal video	
(3) Radar Trigger	Level	10 to 50 volts peak	50 volts peak max Output level stability: ±1 db for input level variations of from 10 to 50 volts peak
	Impedance	Source: 75 ohms	Load: 75 ohms

Table 3-1 A (Continued)

Signal Designation	Signal Characteristics	Input at Search Terminal	Output at IFR-Search Terminal
(3) Radar Trigger (Cont)	Polarity	Positive	Positive
	Rise Time	0.2 μsec max	0.2 μsec max
	Pulse Width	1.7 μsec ±10 %	1.7 μsec ±10 %
	Repetition Rate	Less than 1000 pulses per second	Same as input
	Overshoot	Assume none, as reference	Less than 5%
	Time Jitter	Assume none, as reference	Less than 0.02 μsec
	Amplitude Jitter	Assume none, as reference	Less than ±1 db
(4) Radar Pre-Trigger	Level	10 to 50 volts peak	40 volts peak max (adjustable). Output level stability: ±1 db for input level variations of from 10 to 50 volts peak
	Impedance	Source: 75 ohms	Load: 50 ohms
	Polarity	Positive	Positive
	Rise Time	0.2 μsec max	0.2 μsec max
	Pulse Width	1.7 μsec ±10 %	1.7 μsec ±10 %
	Overshoot	Assume none, as reference	Less than 5%
	Jitter a. Time	Assume none, as reference	Less than 0.02 μsec
	b. Amplitude	Assume none, as reference	Less than ±1 db

Table 3-1 A (Continued)

Signal Designation	Signal Characteristics	Input at Search Terminal	Output at IFR-Search Terminal
(5) Beacon Video	Level	2.5 volts peak max	3 volts peak max (adjustable)
	Gain		Gain: zero ±1.5 db for input levels from 0.1 to 2.5 volts
	Impedance	Source: 75 ohms	Load: 75 ohms
	Polarity	Positive	Positive
	Rise Time	0.2 μsec max	Not more than 0.225 μsec for input rise time of 0.2 μsec
	Overshoot	Assume none, as reference	Less than 10% for a pulse having a rise time of 0.3 μsec
	Droop	Assume none, as reference	Less than 10% for a 1000 μsec pulse at 250 cps
	Jitter a. Time	Assume none, as reference	Not more than 0.02 μsec
	b. Amplitude	Assume none, as reference	Less than 1 db
(6) Antenna Azimuth Rotational Data		The specified inputs are three resolver rotor voltages as follows: 1. One speed (coarse) 2. Ten speed (fine) 3. Resolver reference	The specified output is 1 speed 400 cycles per second synchro rotational data
	Levels	Levels: 0.5 volts rms at 426.6 cps	Capable of driving not less than four Admiral Model 2121 PPI's
	Error	Assume no error at input	Error at microwave synchro output shall not exceed 0.1° for any rotational speed from 0 to 15 rpm, and no readjustments shall be required for changes in rotational speed

Table 3-1 A. (Continued)

Signal Designation	Signal Characteristics	Input at Search Terminal	Output at IFR-Search Terminal
(7) Order wire communications	Response	Voice input into microphone attached to order wire unit. Frequency range 300 to 3000 cps	Audible voice output from speaker. Audio bandwidth from electrical input at microphone to electrical output at speaker: within ±3 db from 300 to 3000 cps
	Distortion	For reference, assume no distortion at input	Not more than 5 percent at 1000 cps for same input and output conditions listed above

Table 3-1 (Continued)

B. Transmission From IFR Center to Search Radar

Signal Designation	Signal Characteristic	Input at IFR-Search Terminal	Output at Search Terminal
(1) Beacon Trigger	Level	40 to 60 volts peak	50 volts peak max
			Output level stability: ±1 db for variations of from 40 to 60 volts peak input level
	Impedance	Source: 75 ohms	Load: 75 ohms
	Polarity	Positive	Positive
	Rise Time	0.2 μsec max	0.08 μsec ±20%
	Pulse Width	0.9 μsec ±0.1 μsec	0.9 μsec ±0.1 μsec
	Pulse Spacing	2.8 μsec max	Input spacing reproduced within ±0.1 μsec
	Pulse Pair Repetition Frequency	All frequencies from 150 to 500 pulses per second	Same as input
	Jitter		
	a. Time	Assume none, as reference	Not more than 0.05 μsec
	b. Amplitude	Assume none, as reference	Less than plus or minus 1 db
	Overshoot	Assume none, as reference	Less than 5%

Table 3-1 B (Continued)

Signal Designation	Signal Characteristics	Input at IFR-Search Terminal			Output at Search Terminal		
(2) Normal Video IF Gain Control		Three state dc control level			Three state dc control level		
	State	ON	OFF	ON	ON	OFF	ON
	Level	zero volts (gnd)	open circuit	zero volts (gnd)	zero volts	open circuit	zero volts
	Source Impedance	zero ohms	infinite	zero ohms	zero ohms	infinite	zero ohms
	Time Delay				A time delay of not more than 40 milliseconds between contact closure at the sending end and closure at receiving end is required. Protection from false operation during a fade is also required.		
(3) MTI IF Gain Control	Same as above	Same as above			Same as above		
(4) Beacon (IFF) Receiver IF Gain Control	Same as above	Same as above			Same as above		
(5) STC Gain Control	Same as above	Same as above			Same as above		

Table 3-1 B (Continued)

Signal Designation	Signal Characteristics	Input at IFR-Search Terminal		Output at Search Terminal	
(6) FTC IN/OUT Control		Two state dc control level		Two state dc control level	
	State	IN	OUT	IN	OUT
	Level	zero volts	open circuit	zero volts (gnd)	open circuit
	Source Impedance	zero ohms	infinite	zero ohms	infinite
	Time Delay			A time delay of not more than 40 milliseconds between contact closure at the sending end and closure at receiving end is required. Protection from false operation during a fade is also required	
(7) Circular Polarization IN/OUT Control	Same as above	Same as above		Same as above	
(8) Pulse Width Discrimination IN/OUT Control	Same as above	Same as above		Same as above	
(9) STC IN/OUT Control	Same as above	Same as above		Same as above	

Table 3-1 B (Continued)

Signal Designation	Signal Characteristics	Input at IFR-Search Terminal	Output at Search Terminal
(10) Order Wire Communications	Response	Voice input into microphone attached to order wire unit. Frequency range 300 to 3000 cps	Audible voice output from speaker. Audio bandwidth from electrical input at microphone to electrical output at speaker: within ±3 db from 300 to 3000 cps
	Distortion	For reference, assume no distortion at input	Not more than 5% at 1000 cps for same input and output conditions listed above

Table 3-2. Requirements of IFR-PAR microwave link

A. Transmission From Precision Approach Radar to IFR Center

Signal Designation	Signal Characteristics	Input at PAR Terminal	Output at IFR-PAR Terminal
(1) Normal Video	Level	4 volts peak max	4.0 volts peak max (adjustable) Gain: Zero ±1.5 db for input levels from 0.2 to 4 volts peak
	Impedance	Source: 50 ohms	Load: 50 ohms
	Polarity	Positive	Positive
	Rise Time	0.5 μsec	Not more than 0.1 μsec for input rise time of 0.05 μsec
	Overshoot	Assume none, as reference	Less than 10% for pulse having a rise time of 0.1 μsec
	Droop	Assume none, as reference	Not more than 5% for a 300 μsec pulse
	Jitter a. Time	Assume none, as reference	Not more than 0.02 μsec
	b. Amplitude	Assume none, as reference	Less than ±1 decibel
(2) Radar Trigger	Level	15 to 25 volts peak	25 volts peak max (adjustable) Output Level Stability: ±1 decibel for variations of from 10 to 30 volts peak input level
	Impedance	Source: 50 ohms	Load: 50 ohms

Table 3-2 A (Continued)

Signal Designation	Signal Characteristics	Input at PAR Terminal	Output at IFR-PAR Terminal
(2) Radar Trigger (Cont)	Polarity	Positive	Positive
	Pulse Width	0.2 μsec	0.2 μsec
	Rise Time	0.05 μsec	Not more than 0.1 μsec
	Repetition Rate	1200 pulses per sec	Same as input
	Overshoot	Assume none, as reference	Less than 5%
	Jitter		
	a. Time	Assume none, as reference	Less than 0.02 μsec
	b. Amplitude	Assume none, as reference	Less than ±1 decibel
(3) Azimuth position of azimuth scan antenna	Level	0 to +50 volts for 30 or 60° scan	0 to +50 volts
	Impedance	Source: 200 to 1000 ohms	Load: Not less than 2000 ohms
	Scan Rate	Scan Rate: 100 volts per sec max for 60° per sec max	100 volts per sec max rate of change
	Error	Input: Not more than the equivalent of 0.1° max	Output: Not more than the equivalent of 0.2° with specified input error, from stationary to maximum rate of scan regardless of direction of scan

Table 3-2 A (Continued)

Signal Designation	Signal Characteristics	Input at PAR Terminal	Output at IFR-PAR Terminal
(4) Elevation (tilt) position of azimuth scan antenna	Level	0 to -22 volts for 25° tilt range	0 to -22 volts
	Impedance	Source: 0 to 1000 ohms	Load: Not less than 15,000 ohms
	Slewing Rate	2.2 volts per sec max for 2.5° per sec	2.2 volts per sec max rate of change
	Error	Input: Not more than the equivalent of 0.1° max	Output: Not more than the equivalent of 0.35° with specified input error, from stationary to maximum rate regardless of direction of travel
(5) Elevation position of elevation scan antenna	Level	0 to +50 volts for 11 or 35° scan	0 to +50 volts
	Scan Rate	100 volts per sec max for 70° per sec max	100 volts per sec max rate of change
	Error	Input: Not more than the equivalent of 0.1° max	Output: Not more than the equivalent of 0.2° with specified input error, from stationary to max rate of scan regardless of direction of scan

Table 3-2 A (Continued)

Signal Designation	Signal Characteristics	Input at PAR Terminal		Output at IFR-PAR Terminal	
(6) Azimuth position of elevation scan antenna	Level	0 to -16 volts for 30° servo range		0 to -16 volts	
	Impedance	Source: 0 to 1400 ohms		Load: Not less than 34,000 ohms	
	Slewing Rate	1.6 volts per sec max for 2.5° per sec		1.6 volts per sec max rate of change	
	Error	Input: Not more than the equivalent of 0.1° max		Output: Not more than the equivalent of 0.35° with specified input error, stationary to max rate, regardless of direction of travel	
(7) Unblanking Gate	State	UNBLANKED	BLANKED	UNBLANKED	BLANKED
	Level	0 volts	Open circuit	0 volts (gnd)	Open circuit
	Impedance	0 ohms (source)	Infinite (source)	500 ohms (load)	500 ohms (load)
	Rise Time	1 millisecond max		Combined rise time and envelope delay of not more than two milliseconds.	
	Decay Time	1 millisecond max		Combined decay time and envelope delay of not more than two milliseconds	
	Time Jitter	Assume none, as reference		Not more than 200 µsec	

Table 3-2 A (Continued)

Signal Designation	Signal Characteristic	Input at PAR Terminal		Output at IFR-PAR Terminal	
(8) Relay Gate	State	ON	OFF	ON	OFF
	Level	Plus 28 volts	0 volts	Plus 28 volts	0 volts
	Impedance	Less than 10 ohms (source)	500 ohms (source)	135 ohms (load)	135 ohms (load)
	Rise Time	1 millisecond max		Combined rise time and envelope delay of not more than two milli-seconds.	
	Decay Time	1 millisecond max		Combined decay time and envelope delay of not more than two milli-seconds	
	Time Jitter	Assume none, as reference		Not more than 200 μsec	
(9) High voltage on-off indication		Two state dc control level		Two state dc control level	
	State	ON	OFF	ON	OFF
	Level	Plus 28 volts	open circuit	Plus 28 volts	Zero volts
	Impedance	Low (source)	Infinite ohms (source)	Low (source)	Infinite (open circuit)

Table 3-2 A (Continued)

Signal Designation	Signal Characteristic	Input at PAR Terminal	Output at IFR-PAR Terminal
(9) High voltage on-off indication (Cont)	Time Delay		A time delay of not more than 40 milliseconds between contact closure at the sending end and closure at receiving end is required
(10) Order wire communications	Response	Voice input into microphone attached to order wire unit. Frequency range 300 to 3000 cps	Audible voice output from speaker. Audio bandwidth from electrical input at microphone to electrical output at speaker: within ±3 db from 300 to 3000 cps
	Distortion	For reference, assume no distortion at input	Not more than 5% at 1000 cps for same input and output conditions listed above

Table 3-2 (Continued)

B. Transmission from IFR Center to Precision Approach Radar

Signal Designation	Signal Characteristics	Input at IFR-PAR Terminal			Output at PAR Terminal		
(1) Azimuth IF gain control		Three-state dc control level			Three-state dc control level		
	State	ON	OFF	ON	ON	OFF	ON
	Level	zero volts (gnd)	open circuit	zero volts (gnd)	zero volts (gnd)	open circuit	zero volts (gnd)
	Impedance: (Source)	zero ohms	infinite	zero ohms			
	(Load)				500 ohms	500 ohms	500 ohms
(2) Elevation IF gain control	Same as above	Same as above			Same as above		
(3) Elevation (tilt) control of azimuth scan antenna		Three-state dc control level			Three-state dc control level		
	State	ON	OFF	ON	ON	OFF	ON
	Level	-28 volts	0 volts	-28 volts	-28 volts	0 volts	-28 volts
	Impedance: (Source)	approx 0	infinite	approx 0 ohms			
	(Load)				500 ohms	500 ohms	500 ohms
(4) Azimuth control of elevation scan antenna	Same as above	Same as above			Same as above		

Table 3-2 B (Continued)

Signal Designation	Signal Characteristics	Input at IFR-PAR Terminal			Output at PAR Terminal		
(5) High voltage ON/OFF		Function is equivalent to a three-state dc control			Function is equivalent to a three-state dc control		
Circuit #1	State	ON	NEUTRAL	OFF	ON	NEUTRAL	OFF
(HV ON)	Level	0 volts (gnd)	open circuit	open circuit	0 volts (gnd)	open circuit	open circuit
	Impedance:						
	(Source)	0 ohms	infinite	infinite			
	(Load)				500 ohms	500 ohms	500 ohms
Circuit #2	State						
(HV OFF)	Level	0 volts (gnd)	0 volts (gnd)	open circuit	0 volts (gnd)	0 volts (gnd)	open circuit
	Impedance:						
	(Source)	0 ohms	0 ohms	infinite			
	(Load)				500 ohms	500 ohms	500 ohms
(6) Elevation scan		Two-state dc control level			Two-state dc control level		
mode control	State	11^{o} scan	35^{o} scan		11^{o} scan	35^{o} scan	
Note: The control circuit consists of two wires, one for each scan mode	Level						
	Circuit #1	-28 volts	0 volts		-28 volts	0 volt	
	Circuit #2	0 volts	-28 volts		0 volts	-28 volt	
	IMPEDANCE:						
	Circuit # 1						
	(Source)	approx 0 ohms	open circuit				
	(Load)				500 ohms	500 ohms	
	Circuit # 2						
	(Source)	open circuit	approx 0 ohms				
	(Load)				500 ohms	500 ohms	

Table 3-2 B (Continued)

Signal Designation	Signal Characteristics	Input at IFR-PAR Terminal		Output at PAR Terminal	
(7) Azimuth scan mode control	Same as above	Same as above except 11° is replaced by 30° and 35° is replaced by 60°		Same as above except 11° is replaced by 30° and 35° is replaced by 60°	
(8) FTC ON/OFF control		Two-state dc control level			
	State	ON	OFF	ON	OFF
	Level	-28 volts	open circuit	-28 volts	open circuit
	Impedance:				
	(Source)	approx 0 ohms	infinite		
	(Load)			1000 ohms	1000 ohms
(9) Antenna Scan ON/OFF control	Same as above	Same as above		Same as above	
(10) STC ON/OFF control		Two-state dc control level		Two-state dc control level	
	State	ON	OFF	ON	OFF
	Level	0 volts(gnd)	-35 volts	0 volts(gnd)	-35 volts
	Impedance:				
	(Source)	0 ohms	low		
	(Load)			270, 000 ohms	270, 000 ohm

Note: For all preceding control functions (1 through 10) a time delay of not more than 40 milliseconds between contact closure at the sending end and closure at receiving end is required. Protection from false operation during a fade is also required.

Table 3-2 B (Continued)

Signal Designation	Signal Characteristics	Input at IFR-PAR Terminal	Output at PAR Terminal
(11) Order Wire communications	Response	Voice input into microphone attached to order wire unit. Frequency range 300 to 3000 cps	Audible voice output from speaker Audio bandwidth from electrical input at microphone to electrical output at speaker: within ±3 db from 300 to 3000 cps
	Distortion	For references, assume no distortion at input	Not more than 5% at 1000 cps for same input and output conditions listed above

3.2 GENERAL DISCUSSION OF EQUIPMENT REQUIRED

Each microwave link will consist of two terminals, one at each end of the link. For the IFR-search link, the terminal at the search radar will be designated as the search terminal, and the terminal at the IFR center will be designated as the IFR-search terminal. For the IFR-PAR link, the terminal at the precision approach radar will be designated as the PAR terminal and the terminal at the IFR center will be designated as the IFR-PAR terminal.

The microwave link consists of microwave channels in each direction. Each microwave channel is transmitted from one terminal via a fm microwave transmitter, and is received at the opposite terminal via a companion receiver operating on the same frequency. One parabolic antenna is used at each terminal for simultaneous transmission and reception. Several types of data may be simultaneously transmitted over a given microwave channel by frequency or time multiplexing the signals on the video baseband.

Radar video and trigger data is combined by a video, trigger (VT) multiplexer; or a video, video, trigger (VVT) multiplexer for modulation of the microwave transmitter. The VT multiplexer utilizes a combination of polarity and time multiplexing, and the VVT multiplexer uses the same method plus frequency multiplexing of the second video channel. At the opposite terminal, the output of the microwave receiver is applied to compatible demultiplex equipment which separates the radar video and trigger.

Additional frequency multiplexing is accomplished by subcarrier transmitters which are frequency modulated by various data signals. The subcarrier transmitters are assigned specific frequencies (within the video baseband) and the output modulates the microwave transmitter. At the opposite terminal a subcarrier receiver assigned

to the same frequency band separates the desired subcarrier signal from the other multiplexed signals present at the output of the microwave receiver. The output of the subcarrier receiver is applied to the appropriate equipment for further processing.

Still further frequency multiplexing is employed for two and three state dc control signals by converting them to audio tones on different frequencies. These tones are combined and used to modulate an fm subcarrier transmitter. At the receiving end, the output of the companion subcarrier receiver is applied to the appropriate tone (voice frequency carrier) demultiplex equipment. Time multiplexing may be employed in place of frequency multiplexing for the control signals by utilizing sequential scanning equipment.

In addition to the multiplex equipment required for combining several signals on one microwave channel, additional equipment is required for converting some signals into a form suitable for transmission via subcarrier channels, and/or for reconversion at the opposite terminal. This equipment is as follows: Gate converter and gate generator for gate signals (switched dc levels). Analog data transmitter and analog data receiver for PAR elevation and azimuth antenna data (continuously variable dc levels). Electronic control amplifier and synchro assembly for search radar antenna azimuth data.

A power distribution panel is required at each terminal for protection and distribution of primary power. Separate power supplies for the rf equipment (microwave receivers and transmitters) and the multiplex equipment are also required.

A monitor panel is necessary for monitoring, transferring, or terminating the composite signal to the microwave transmitter or from the microwave receiver. For voice communications between terminals, an order wire unit is needed.

For installation of the equipment in shelters, standard 19-inch equipment racks are required.

3.3 POTENTIALLY APPLICABLE MICROWAVE EQUIPMENT AVAILABLE

A discussion of the survey of potentially applicable microwave equipments was contained in the previous report (AFCRL 500). Of the 14 potential suppliers contacted, three were determined to have applicable microwave equipment. These were Collins, Motorola, and Raytheon. The relative advantages and disadvantages of the equipment from the three suppliers are summarized below:

Microwave Manufacturer	Advantages	Disadvantages
Collins	a. Equipment is lightest of three. Uses aluminum chassis and racks.	a. Does not meet military specifications. This is especially true of mechanical structure.
	b. Requires least rack space.	b. Units are not attached to rack at center of gravity.
	c. Least expensive	
	d. Majority of units are hinged on one side and can be swung out from rack for ease of maintenance	
	e. Can be provided with 10 mc video bandwidth.	
Motorola	a. Designed to meet military specifications.	a. Weighs approximately 25% more than Collins equipment. Also may require 10-25% more rack space.

Microwave Manufacturer	Advantages	Disadvantages
Motorola (continued)	b. Supports for holding equipment in rack are attached to chassis at center of gravity.	b. Units are bolted in rack and special pivoted rack is required in order to allow equipment to be swung out for maintenance.
		c. Max. video bandwidth is 7.5 Mc.
Raytheon	a. Can be provided with 15 mc video bandwidth.	a. Does not meet military specifications.
	b. Microwave receivers and transmitters have internal power supplies. This should improve reliability. RF equip. of other two manufacturers operates from common power supply and failure would cause all channels of a given microwave terminal to be inoperative.	b. Approximately twice as heavy as Collins equipment and requires twice as much rack space.
	c. Transmitters have 1 watt output which is 10 to 13 db more than that of other two manufacturers.	c. Requires external waveguide plumbing for diplexing. This is not required by the equipment of the other two manufacturers.
		d. Individual units do not swing out from racks, and availability of pivoted racks was not mentioned, but could probably be designed.

3.4 DETAILED DESCRIPTION OF EQUIPMENT SELECTED

After comparing the microwave equipment from the three manufacturers and evaluating the characteristics against the requirements of project A4W, CSL decided that microwave equipment meeting military specifications was the most desirable. This resulted in a decision to specify equipment similar to that of the AN/GRQ-6 which is a radar data transfer (microwave) system being manufactured for the Air Force by Motorola.

After determining the manufacturer, it was then possible to select the type and quantity of equipment required for the two microwave links. Table 3-3 is a list of the equipment, the size and weight, the primary power consumption, and the quantity required at each location. The individual items of microwave equipment are described in the following paragraphs. The numbering sequence of each item is the same as that in Table 3-3:

1. Microwave Transmitter

   The microwave transmitter is utilized to transmit radar data, control, and voice signals as required to the microwave receiver at the opposite end of the microwave link. The signals are multiplexed on the transmitter video channel by means of bipolar multiplexing, fm subcarriers, and voice frequency carriers ([illegible] tones). The converted signals are then combined and utilized to frequency modulate the microwave transmitter. The transmitter operates in the 7750 to 8400 Mc frequency band and has a frequency deviation of ± 3 Mc and a nominal video bandwidth from 20 cps to 7.5 Mc within 1.5 db. The power output is 100 mw nominal, 55 mw minimum. The outputs of several transmitters may be combined for simultaneous transmission via a single antenna, provided the frequency separation between adjacent transmitters is not less

than 45 mc. The transmitter has automatic frequency control which is referenced to a cavity, and can maintain frequency within ±0.01 percent. An alarm transmitter is also provided to send a sensing signal on the video band at 7.0 Mc to enable monitoring the channel for failure indication at the opposite terminal.

2. Microwave Receiver

The Microwave Receiver converts, amplifies and demodulates the microwave signal from a companion transmitter at the opposite end of the microwave link. The receiver output is applied to appropriate demultiplex equipment. The receiver operates in the 7750 to 8400 Mc frequency band and has a nominal IF bandwidth of 24 Mc, and a video bandwidth of 20 cps to 7.5 Mc within 1.5 db. Automatic frequency control (AFC) is employed by the receiver to lock on the transmitter frequency. Pull-in range of the AFC is ±10 Mc. The noise figure of the microwave receiver is 15 db. An alarm receiver is included to sense the 7.0 Mc alarm signal and provide an indication of channel degradation or failure. Simultaneous reception and transmission via a single antenna can be accomplished provided receivers are separated from adjacent transmitters by more than 90 Mc.

The microwave receivers may be mounted in standard racks in the same manner as the transmitters and may be coupled to other receivers or to transmitters by internal waveguide sections identical to those provided for coupling the transmitters.

3. RF Power Supply

The RF power supply provides regulated dc voltages for operation of the microwave transmitters and receivers. A total of three transmitters or receivers, or combinations thereof may

be operated from one power supply. The power supply mounts in a standard 19-inch rack.

4. Cooler, Electrical Equipment (Blower)

   The blower is provided to circulate cooling air through the microwave transmitters and receivers. The blower is attached to a panel which mounts in a standard rack. A duct is attached on one side of the rack to convey the air to the transmitter(s) and receiver(s).

5. Video, Trigger (VT) Multiplexer

   The VT multiplexer combines the video and trigger signals into a composite bipolar video signal which is applied to the microwave transmitter. The video is transmitted with positive polarity and the trigger pulses are transmitted with negative polarity. This technique enables separation of the video and trigger at the opposite terminal. The trigger occurs ahead of the video and therefore does not interfere. Power requirements for the VT multiplexer are supplied by a common multiplexer power supply which is capable of supplying several multiplex equipments.

6. Video, Video, Trigger (VVT) Multiplexer

   The VVT multiplexer combines two video and one trigger signal into a composite signal for transmission via the microwave transmitter. One video signal and the trigger signal are combined in the same manner as with the VT multiplexer above, and the other video signal amplitude modulates a carrier frequency which is above the frequency of the video band of the composite bipolar signal. The signals are combined for application to the microwave transmitter. Power from a multiplexer power supply if required.

7. Video, Trigger (VT) Demultiplexer

The VT demultiplexer receives a composite signal from the microwave receiver and filters out the composite video and trigger signal which is then converted into a separate video and trigger outputs. Power for the VT demultiplexer is obtained from a multiplex power supply.

8. Video, Video, Trigger (VVT) Demultiplexer

The VVT demultiplexer receives a composite signal from the microwave receiver and separates the bipolar video and the amplitude modulated carrier by means of filters. The signals are further processed and supplied as separate video, video and trigger outputs. The VVT demultiplexer requires power from a multiplex power supply.

9. Subcarrier (SC) Transmitter

The subcarrier transmitter is used to superimpose various data on the video baseband. This is accomplished by modulating the SC transmitter with the data and then modulating the microwave transmitter with the SC transmitter. The SC transmitter is frequency modulated and the center frequency can be set anywhere within the microwave video baseband except at the lowest frequencies. Several subcarrier channels may be combined for transmission over a single microwave channel as long as adequate SC channel separation (nominally 500 kc) is provided. The SC transmitter will handle data in the 25 cps to 45 kc range. Deviation of the SC transmitter is normally ±15 kc.

The subcarrier transmitter is mounted in a frame which will hold three SC transmitters. Operating voltages are obtained from a multiplex power supply.

10. Subcarrier (SC) Transmitter Frame

The SC transmitter frame provides facilities for mounting three SC transmitters along with a panel containing a meter and a switch for monitoring the operation of the SC transmitters. Connector receptacles compatible with the SC transmitter connectors are provided for making connections with the power source, meter panel, and signal inputs and outputs. The SC transmitter frame mounts in a standard 19-inch rack.

11. Subcarrier (SC) Receiver

The composite video signal from the microwave receiver is applied to the SC receiver which filters out all other data signals and amplifies and demodulates the fm signal from the SC transmitter on the opposite end of the microwave link. The output of the SC receiver is applied to additional demultiplex equipment as required. The SC receiver may be set to any frequency on which its companion SC transmitter operates. The rf bandwidth of the subcarrier receiver is ±150 kc and the af bandwidth is 25 cps to 45 kc (3 db).

The SC receiver is mounted in a frame which will hold three SC receivers. Operating voltages are obtained from a multiplex power supply.

12. Subcarrier (SC) Receiver Frame

The subcarrier (SC) receiver frame provides facilities for mounting three SC receivers along with a panel containing a meter and a switch for monitoring the operation of the SC receivers. Connector receptacles compatible with the SC receiver connectors are provided for making connections with the power source, meter panel, and signal inputs and outputs. The SC receiver frame mounts in a standard 19-inch rack.

13. Electronic Control Amplifier

The antenna position information from the search radar is provided in the form of one speed (coarse) and ten speed (fine) resolver tone signals which are shifted in phase relative to a resolver reference signal by an amount which depends upon the azimuth position of the antenna. The frequency of the tones is 426.6 cps. The electronic control amplifier operates in conjunction with a synchro assembly to provide search radar antenna azimuth data to the search indicators at the control center. The inputs to the electronic control amplifier are the three 426.6 cps tones from the microwave link via three subcarrier receivers (if operation is via cable, the input tones come over the cable link), and tones from the synchro assembly. The electronic control amplifier develops coarse and fine error signals proportional to the phase error between the remote resolver signals (from the radar antenna) and similar resolver signals from the synchro assembly. The error signals are amplified and applied to the synchro assembly. The electronic control amplifier normally operates on the fine error signals for maximum accuracy; however, if the error becomes excessive, it switches to the coarse error signal until the error can be corrected enough to allow operation from the fine error signal without ambiguity.

The electronic control amplifier mounts in a standard 19-inch rack. Operating voltages are obtained from a multiplex power supply.

14. Synchro Assembly

The synchro assembly is utilized in conjunction with the electronic control amplifier to provide search radar antenna azimuth data to the search indicators at the control center. The

input to the synchro assembly is the error signal from the electronic control amplifier. The error signal is applied to a servo motor which causes the two resolvers (fine and coarse) to rotate (via a gear train) in a direction to reduce the error to zero. A synchro transmitter is geared to the servo motor and resolvers in a manner to provide 1 speed synchro data to the PPI indicators and the track/symbol unit.

The synchro assembly mounts in a standard 19-inch rack.

15. Multiplex Power Supply

The multiplex power supply provides ac filament voltage and regulated dc voltages for various multiplex equipment. The power supply mounts in a standard 19-inch rack.

16. Monitor Panel

The monitor panel provides facilities for monitoring and/or terminating, and transferring up to six video channels. All input, output, and monitor connectors are BNC type. Selection of terminating resistance is accomplished with a toggle switch. The monitor panel mounts in a standard 19-inch rack.

17. Power Distribution Panel

The power distribution panel distributes and controls the ac primary power to various units in the equipment rack(s). Indicator lamps and circuit breakers are provided for each branch circuit. Convenience outlets are also provided on the distribution panel.

18. Voice Frequency Carrier (VFC) Transmitter - Two State

The VFC (or tone) transmitter is used to convert control signals into audio frequency tones for modulation of subcarrier

transmitters. The two-state transmitter has two frequencies, one of which is transmitted for the first of the two states and the other for the second state. The two states correspond to ON and OFF control signals. The two frequencies correspond to the center frequency minus 42.5 cps and the center frequency plus 42.5 cps. The operating (center) frequencies of the tones are within the range of 500 to 3100 cps with a channel spacing of not less than 170 cps. Frequency of the VFC transmitter may be changed by plug-in units. The outputs of several VFC transmitters are combined and applied to a subcarrier transmitter, the output of which is in turn applied to the microwave transmitter.

The VFC transmitter mounts in a frame which contains an individual power supply for each VFC unit.

19. Voice Frequency Carrier (VFC) Transmitter - Three State

The three-state VFC transmitter is identical to the two state unit except it handles three state (ON/OFF/ON) control signals. This is accomplished by using three frequencies instead of two. These frequencies are: center frequency plus 42.5 cps, center frequency, and center frequency minus 42.5 cps.

The three-state VFC transmitter mounts in the same frame as the two state.

20. Voice Frequency Carrier (VFC) Receiver - Two or Three State

The VFC receiver converts the tones transmitted by the companion VFC transmitter at the opposite end of the microwave link into the proper control signal. The input to the VFC receiver consists of the combined tones from a subcarrier receiver. The VFC receiver filters out all tones except those on

its assigned VFC channel. Tones on the assigned channel (center frequency ± 42.5 cps) are amplified and demodulated to produce proper control outputs in the form of contact closures. The VFC receivers may be converted for either two or three state operation. The operating frequency may be changed by means of plug-in units. Response of a VFC transmitter-receiver combination is such that not more than 40 milliseconds elapse between contact closure on the sending end and contact closure on the receiving end.

The VFC receiver mounts in the same frame as the VFC transmitters.

21. Voice Frequency Carrier (VFC) Receiver - Noise Receiver

The VFC noise receiver monitors an idle VFC channel (one with no transmission) for noise. If the noise becomes excessive, the noise receiver will apply a signal to all other VFC receivers operating on the same subcarrier channel to prevent operation until the noise decreases.

The VFC noise receiver mounts in the same frame as the other VFC receivers and transmitters.

22. Voice Frequency Carrier (VFC) Frame

The VFC frame provides facilities for mounting twelve VFC transmitters or receivers or combinations thereof. Each frame also has space for attaching a small solid state power supply at each VFC transmitter or receiver position. Connector receptacles are provided on the frame for mating the plugs on the VFC receivers or transmitters. The VFC frame mounts in a standard 19-inch rack.

23. Order Wire

The order wire unit provides voice communications over the microwave channels. The unit contains a fm receiver-transmitter which provides simplex voice communication by modulating the microwave transmitter with a fm subcarrier during transmission, and demodulating a fm subcarrier from the microwave receiver during reception. Transmission and reception are accomplished on the same subcarrier frequency. A companion order wire unit on the same frequency is required at the opposite end of the microwave link. The transmitter deviation is nominally ± 16 kc, and the receiver bandwidth is ± 300 kc. Each order wire unit contains a speaker and a microphone. When no signal is being received, the receiver is squelched.

The order wire unit should have the capability of operating as an intercommunications unit over 1000 feet of cable. This feature is not provided by the present (Motorola) unit.

The order wire unit has a self contained power supply and mounts in a standard 19-inch rack.

24. Analog Data (AD) Transmitter

The analog data transmitter would convert dc analog voltages into signals suitable for transmission via fm subcarrier over the microwave link. This equipment has not been designed, and there are two methods of attacking the problem. One method is by converting the voltage level into a serial digital code which would modulate a subcarrier transmitter which would modulate the microwave transmitter. The second method is by converting the voltage level to an analog frequency which would also modulate a subcarrier transmitter, Motorola seems

to prefer the second method because the AD transmitter would be less complex and more economical to build; however, the stability would not equal the digital method.

The data transmitted via the AD transmitter would consist of the azimuth and elevation positions of the azimuth scan and the elevation scan antennas on the precision approach radar. This would require four AD transmitters.

The AD transmitters would be mounted in an AD transmitter frame. Each AD transmitter would have a self contained power supply.

25. Analog Data (AD) Transmitter Frame

The AD frame, which would mount in a standard 19-inch rack, provides mountings for four AD transmitters. Connector receptacles on the frame provide for mating the AD transmitter plugs.

26. Analog Data (AD) Receiver

The AD receiver would receive, via fm subcarrier, the signal corresponding to the converted analog voltage from the precision approach radar. The AD receiver would reconvert this signal to a voltage level corresponding to the input at the opposite end of the microwave link. This voltage would be applied to the PAR indicators at the control center. This equipment has not been designed, but will have to be compatible with the AD transmitter. Accuracy requirements (input to output) of the AD transmitter and receiver combination are approximately 0.15 percent.

The AD receiver would be mounted in an AD receiver frame. Each AD receiver would have a self-contained power supply.

27. Analog Data (AD) Receiver Frame

The AD receiver frome would provide facilities for mounting four AD receivers. Connector receptacles would be provided

on the frame for mating the plugs on the AD receivers. The AD receiver frame would mount in a standard 19-inch rack.

28. Gate Signal Converter

The gate signal converter would be capable of converting two gate signals into signals suitable for transmission via two subcarrier channels. The signals to be transmitted are the unblanking gate and the relay gate of the precision approach radar. The equipment has not been designed, but would be relatively simple. The converter would essentially be a differentiation circuit which would convert the positive going edge of the gate signal to a positive pulse and the negative going edge to a negative pulse. The output would modulate a subcarrier transmitter which would modulate the microwave transmitter.

The gate signal converter would mount in a standard 19-inch rack.

29. Gate Generator

The gate generator will receive the positive and negative pulses corresponding to the two gate signals (unblanking gate and relay gate) via two subcarrier channels and will regenerate the original gate signals. The equipment has not been designed but will be relatively simple. The gate generator would contain a bistable multivibrator (flip-flop) for each gate signal. The flip-flop would be set and reset according to the polarity of the input pulses and would drive an amplifier, the output of which would be the regenerated gate signal.

The gate generator would have a self-contained power supply and would mount in a standard 19-inch rack.

30. RF Attenuator

The RF attenuator is used for determining microwave signal fade margin at the search microwave terminal and the PAR microwave terminal. The attenuator is a 0 to 50 db continuously variable direct reading model which is inserted in the waveguide between the rf equipment (transmitters and receiver) and the microwave antenna. Fade margin can be determined directly by increasing the attenuation and noting at what value the failure alarm operates at the receiving end of a given microwave channel.

The attenuator is mounted in the rack directly above the rf equipment.

31. Rack, Door Frame

This type rack has pivots on the left side at both the top and bottom. The pivots allow the rack to be rotated about a vertical axis through an angle of more than 90 degrees for inspection and repair or removal and installation of equipment. The rack is locked in the normal position by captive bolts with T handles at the top and bottom on the right side of the rack. The pivots are attached to shocks on the left, and the captive bolts screw into shock mounted plates on the right. The pivot at the top left has an opening large enough to allow a waveguide to pass through.

All microwave equipment is mounted in these racks. When the racks are installed, care must be taken to allow adequate clearance for the racks to swing.

32. Air Duct

The air duct is used to convey cooling air from the blower to the microwave receiver(s) and transmitter(s). The duct is mounted along the left side of the rack and has openings at each receiver and transmitter.

33. Demultiplexer and Trigger Generator

The demultiplexer and trigger generator is used to regenerate the beacon (IFF) trigger pulses for triggering the beacon transmitter. Normally, a VT demultiplexer would be used, but the output level is not great enough. The input of the trigger generator is the same as the video section of a VT demultiplexer (see paragraph 7). However, after the input circuits the video (beacon trigger) pulses drive a flip-flop which controls the triggering of two blocking oscillators. The blocking oscillators are operated alternately by the trigger pulses and the blocking oscillator pulses are combined in a common output which triggers the beacon transmitter. Blocking oscillators are used because of the high peak voltage output pulse required. The requirement for two blocking oscillators operating alternately results from the close spacing of the beacon trigger pulses which would not allow a single blocking oscillator to recover.

The trigger generator is mounted in a standard 19-inch rack. A multiplex power supply is required to provide the operating voltages.

34. Antenna -4 foot Diameter

A 4-foot diameter parabolic antenna is used at the search microwave terminal and the IFR-search microwave terminal. This size is required to assure adequate signal strength with the maximum path length (15 miles). The gain of the antenna

is 36 db and the beamwidth is 2.5 degrees. The antenna is attached to a vertical pipe above the shelter.

35. Antenna Mount - 4 foot Antenna

The antenna mount is used to attach the antenna to the mast (vertical pipe). The antenna mount allows adjustment of the antenna in both azimuth and elevation, yet has sufficient rigidity to hold position accurately during severe environmental conditions (ice and wind).

36. Radome - 4 foot Antenna

The radome is used to protect the 4-foot antenna and the feedhorn from the elements. Heating wires are contained in the radome to prevent the formation of ice. The radome can be easily installed on or removed from the antenna.

37. Antenna - 2 foot Diameter

A 2-foot diameter parabolic antenna is used at the PAR microwave terminal and the IFR-PAR microwave terminal. This size is adequate for the maximum required path length (5 miles). The gain of the antenna is 30 db and the beamwidth is 5.0 degrees. The antenna is attached to a vertical pipe above the shelter.

38. Antenna Mount - 2 foot Antenna

The antenna mount is used to attach the antenna to the mast (vertical pipe), and allows adjustment of the antenna in both azimuth and elevation, but has sufficient rigidity to hold position accurately during severe environmental conditions (ice and wind).

39. Radome - 2 foot Antenna

The radome is used to protect the 2-foot antenna and the feedhorn from the elements. Heating wires are contained in the radome to prevent the formation of ice. The radome can be easily installed on or removed from the antenna.

40. Vertical Pipe Mount - Antenna

The vertical pipe mount is the assembly to which the antenna(s) is/are attached and consists of the mast, associated braces, and mounting plates for installation on a shelter. Since the antenna configuration will be different at each shelter (IFR, search, and PAR), the equipment will probably vary somewhat for each shelter.

41. Feed-thru Flange

The feed-thru flange is used to allow the waveguide to pass through the roof of the shelter and up to the antenna. It also includes the feed-thru connector for the radome heater cable.

42. Cross Guide Coupler

The cross guide coupler is inserted in the waveguide between the rf equipment (microwave transmitter(s) and receiver(s) and the antenna. It provides a test point for coupling into the waveguide. It eliminates the necessity of removing the waveguide to make tests on the microwave receiver or transmitter.

43. Beacon (IFF) Receiver Gain Control Adapter

This unit contains a motor driven potentiometer and associated relays (if required) to allow the beacon receiver gain to be controlled remotely via a three state VFC channel. The unit mounts in a standard 19-inch rack near the beacon (IFF) receiver.

Table 3-3. List of microwave equipment physical characteristics, status, and quantity requirements

Item No.	Name	MIL Nomen	Motorola Nomen	Dimensions Inches (Connectors not included) H	W	D	Remarks	Availability Status*	Weight lbs
1	Microwave Transmitter	T-576/GR	RA-314	7	18	14-1/2	Connector 3-1/2"**	M-1	41.7
2	Microwave Receiver	R-710/GR	RA-312	7	18	4-5/8	Connector 3-1/2"**	M-1	35.5
3	RF Power Supply	PP-1337/GR	RU-324	7	18	16-1/2	**	M-2	60.0
4	Cooler, Electrical Equipment (Blower)	HD-482/FR	RU-353	8-3/4	18	10-5/8	**	OS	15
5	Video, Trigger (VT) Multiplexer	TD-128/GR	RU-335	1-3/4	18	8	**	M-1	2.6
6	Video, Video, Trigger (VVT) Multiplexer	TD-127/GR	RU-334	3-1/2	18	5	**	M-1	3.5
7	Video, Trigger (VT) Demultiplexer	TD-125/GR	RU-332	3-1/2	18	5	**	M-1	4.3
8	Video, Video, Trigger (VVT) Demultiplexer	TD-126/GR	RU-333	5-1/4	18	5	**	M-1	6.5
9	Subcarrier Transmitter	0-397/GR	RU-319	2-5/8	8-3/4	6-1/4	** Do not add connector	OS	1.7
10	Subcarrier Transmitter Frame	MT-2245/trt-4	RU-311	5-1/4	18	4	***	OS	4
11	Subcarrier Receiver	R-727/GR	RU-327	2-5/8	8-1/2	6-1/4	** Do not add connector	OS	1.5
12	Subcarrier Receiver Frame	MT-2246/ TRR-9	RU-312	5-1/4	18	4	****	OS	4

Table 3-3. List of microwave equipment physical characteristics, status, and quantity requirements

MIL Nomen	Motorola Nomen	Dimensions Inches (Connectors not included) H	W	D	Remarks	Availability Status*	Weight lbs	Power 120 v ac amp	watts	Quantity Required Search Shelter	PAR Shelter	IFR Shelter
76/GR	RA-314	7	18	14-1/2	Connector 3-1/2"**	M-1	41.7	2.17	260	2	2	2
10/GR	RA-312	7	18	4-5/8	Connector 3-1/2"**	M-1	35.5	1.75	210	1	1	4
-1337/GR	RU-324	7	18	16-1/2	**	M-2	60.0	2.5	300	1	1	2
-482/FR	RU-353	8-3/4	18	10-5/8	**	OS	15	0.05	6	1	1	1
-128/GR	RU-335	1-3/4	18	8	**	M-1	2.6	-	-	1	1	1
-127/GR	RU-334	3-1/2	18	5	**	M-1	3.5	-	-	1	-	-
-125/GR	RU-332	3-1/2	18	5	**	M-1	4.3	-	-	-	-	-
-126/GR	RU-333	5-1/4	18	5	**	M-1	6.5	-	-	-	-	1
97/GR	RU-319	2-5/8	8-3/4	6-1/4	** Do not add connector	OS	1.7	-	-	3	7	2
-2245/trt-4	RU-311	5-1/4	18	4	***	OS	4	-	-	1	3	1
27/GR	RU-327	2-5/8	8-1/2	6-1/4	** Do not add connector	OS	1.5	-	-	1	1	10
-2246/ R-9	RU-312	5-1/4	18	4	****	OS	4	-	-	1	1	4

Table 3-3. (Continued)

Item No.	Name	MIL Nomen	Motorola Nomen	Dimensions Inches H (Connectors not included)	W	D	Remarks	Availability Status*	Weight lbs	Power 120 amp
13	Electronic Control Amplifier	AM-1388/GR	RU-305	8-3/4	18	8-1/2	**Cable Connector 3-1/4"	M-1	13.5	1.35
14	Synchro Assembly	PD-51/GR	RU-320	5-1/4	18	17-1/4	**	M-1	29.3	--
15	Multiplex Power Supply	PP-1338/GR	RU-325	5-1/4	18	17	**	M-1	51	2.3
16	Monitor Panel	SB-1069/TR	RU-330	3-1/2	18	5-3/4		OS	3.2	-
17	Power Distribution Panel	SB-633/GR	RU-329	3-1/2	18	2-1/2	**Connector 3-3/4	M-1	3.5	-
18	VFC Transmitter (Two State)	T-824/FR	RA-302	3-7/8	4-1/4	13-7/8	** Do not add connector	OS	5.0	0.004
19	VFC Transmitter (Three State)	T-821/FR	RA-304	3-7/8	4-1/8	13-7/8	** Do not add connector	OS	5.0	0.004
20	VFC Receiver (Two or Three State)	R-1049/FR	RA-307	3-7/8	4-1/8	13-1/8	** Do not add connector	OS	5.0	0.013
21	VFC Receiver (Noise Receiver)	R-1050/FR	RA-310	3-7/8	4-1/8	13-7/8	** Do not add connector	OS	5.0	0.013
22	VFC Frame	MT-2499/FR	RU-304	14	18	17-3/4	** Do not add connector	OS	17	--
23	Order Wire	RT-357/GR	RU-328	7	18	10-1/4	**	M-1	26.8	0.75
24	Analog Data Transmitter	None	None	5-1/2	8-1/4	13	** Do not add connector	D	15	0.4

Table 3-3. (Continued)

MIL omen	Motorola Nomen	Dimensions Inches H (Connectors not included)	W	D	Remarks	Availability Status*	Weight lbs	Power 120 v ac amp	watts	Quantity Required Search Shelter	PAR Shelter	IFR Shelter
1388/GR	RU-305	8-3/4	18	8-1/2	**Cable Connector 3-1/4"	M-1	13.5	1.35	162	-	-	1
51/GR	RU-320	5-1/4	18	17-1/4	**	M-1	29.3	--	--	-	-	1
338/GR	RU-325	5-1/4	18	17	**	M-1	51	2.3	276	2	2	3
069/TR	RU-330	3-1/2	18	5-3/4		OS	3.2	-	-	1	1	2
33/GR	RU-329	3-1/2	18	2-1/2	**Connector 3-3/4	M-1	3.5	-	-	1	1	2
24/FR	RA-302	3-7/8	4-1/4	13-7/8	** Do not add connector	OS	5.0	0.004	0.48	-	1	9
21/FR	RA-304	3-7/8	4-1/8	13-7/8	** Do not add connector	OS	5.0	0.004	0.48	-	-	9
49/FR	RA-307	3-7/8	4-1/8	13-1/8	** Do not add connector	OS	5.0	0.013	1.56	8	10	1
50/FR	RA-310	3-7/8	4-1/8	13-7/8	** Do not add connector	OS	5.0	0.013	1.56	1	1	1
2499/FR	RU-304	14	18	17-3/4	** Do not add connector	OS	17	--	-	1	1	2
357/GR	RU-328	7	18	10-1/4	**	M-1	26.8	0.75	90	1	1	1
	None	5-1/2	8-1/4	13	** Do not add connector	D	15	0.4	48	-	4	-

1

Table 3-3. (Continued)

Item No.	Name	MIL Nomen	Motorola Nomen	Dimensions Inches (Connectors not included) H	W	D	Remarks	Availability Status*	Weight lbs	Po am
25	Analog Data Transmitter Frame	None	None	14	18	17	**	D	17	-
26	Analog Data Receiver	None	None	5	8-1/4	13	** Do not add connector	D	12	0.
27	Analog Data Receiver Frame	None	None	12-1/4	18	17	**	D	16	-
28	Gate Signal Converter	None	None	5-1/4	18	12	**	D	5.0	-
29	Gate Generator	None	None	1-3/4	18	16-1/2	**	D	6.5	0.
30	RF Attenuator	None	FXR W164A	4-1/2	10-1/2	8		OS	5.25	-
31	Rack, Door Frame	MT-1667	None	70.56	21-1/2	3		OS	42	-
32	Air Duct	None	RK-410	66.5	1-1/2	6-1/4	**	OS	10	-
33	Demultiplexer and Trigger Generator	None	None	3-1/2	18	5	**	D	5	-
34	Antenna (4 ft)	AS-1160/FR	Andrews Corp 25026	49-1/2	49-1/2	29	**	OS	44	-
35	Antenna Mount (4 ft)	None	Andrews 19474A	24	28	24		OS	80	-
36	Radome (4 ft)	CW-581/FR	Andrews Corp 25027	50	50	22-1/2		OS	12	4.
37	Antenna (2 ft)	None	Andrews Corp P2-71G	24	24	19-1/2		OS	17	-

Table 3-3. (Continued)

L on	Motorola Nomen	Dimensions Inches (Connectors not included) H	W	D	Remarks	Availability Status*	Weight lbs	Power 120 v ac amp	watts	Quantity Required Search Shelter	PAR Shelter	IFR Shelter
	None	14	18	17	**	D	17	-	-	-	1	-
	None	5	8-1/4	13	** Do not add connector	D	12	0.5	72	-	-	4
	None	12-1/4	18	17	**	D	16	-	-	-	-	1
	None	5-1/4	18	12	**	D	5.0	-	-	-	1	-
	None	1-3/4	18	16-1/2	**	D	6.5	0.5	72	-	-	1
	FXR W164A	4-1/2	10-1/2	8		OS	5.25	-	-	1	1	-
7	None	70.56	21-1/2	3		OS	42	-	-	2	2	3
	RK-410	66.5	1-1/2	6-1/4	**	OS	10	-	-	1	1	1
	None	3-1/2	18	5	**	D	5	-	-	-	-	1
/FR	Andrews Corp 25026	49-1/2	49-1/2	29	**	OS	44	-	-	1	-	1
	Andrews 19474A	24	28	24		OS	80	-	-	1	-	1
/FR	Andrews Corp 25027	50	50	22-1/2		OS	12	4.6	550	1	-	1
	Andrews Corp P2-71G	24	24	19-1/2		OS	17	-	-	-	1	1

Table 3-3. (Continued)

Item No.	Name	MIL Nomen	Motorola Nomen	Dimensions Inches H (Connectors not included)	W	D	Remarks	Availability Status*	Weight lbs	Pow amp
38	Antenna Mount (2 ft)	None	Andrews 19474A	24	28	24		OS	95	-
39	Radome (2 ft)	None	Andrews Corp HR-2	24-1/2	24-1/2	16-3/4		OS	2	1.
40	Vertical Pipe Mount (Antenna)	None	DS6414	55	59-1/2	59-1/2		OS	250	-
41	Feedthru Flange	None	None	11	11	1-1/2		OS	20.5	-
42	Cross Guide Coupler	None	None	4	4	1-7/8		OS	3	-
43	Beacon (IFF) Receiver Gain Control Adapter	None	None	1-3/4	18	6	All data estimated	OS	5	0.

*Availability Status Symbols

OS = Off the Shelf
M-1 = Requires Minor Modification
M-2 = Requires Major Modification
D = Requires Development

**All dimensions are given without mounting flanges. Add 2" for two 1" width mounting flanges (1 for each side). All dimensions are given without cable connectors for over-all depth add 3" except where noted.

***With frame and XMTR installed d

****With frame and RCVR installed

Table 3-3. (Continued)

IL men	Motorola Nomen	Dimensions Inches H (Connectors not included)	W	D	Remarks	Availability Status*	Weight lbs	Power 120 v ac amp	watts	Quantity Required Search Shelter	PAR Shelter	IFR Shelter
	Andrews 19474A	24	28	24		OS	95	-	-	-	1	1
	Andrews Corp HR-2	24-1/2	24-1/2	16-3/4		OS	2	1.25	150	-	1	1
	DS6414	55	59-1/2	59-1/2		OS	250	-	-	1	1	1
	None	11	11	1-1/2		OS	20.5	-	-	1	1	2
	None	4	4	1-7/8		OS	3	-	-	1	1	2
	None	1-3/4	18	6	All data estimated	OS	5	0.1	12	1	-	-

ability Status Symbols

= Off the Shelf
= Requires Minor Modification
= Requires Major Modification
= Requires Development

dimensions are given without mounting es. Add 2" for two 1" width mounting es (1 for each side). All dimensions given without cable connectors for over-epth add 3" except where noted.

***With frame and XMTR installed depth = 6-3/4.

****With frame and RCVR installed depth = 6-3/4

3.5 MODIFICATIONS NECESSARY TO MEET REQUIREMENTS

3.5.1 MICROWAVE EQUIPMENT MODIFICATIONS

Some of the items of microwave equipment available from Motorola will require modification or development.

The column headed "Availability Status" in Table 3-3 shows whether modification or development is needed on the microwave equipment to meet the requirements of A4W.

Items 1, 2, 15, and 23 require minor modifications for operation on 400 cps instead of 60 cps primary power. Item 3 requires major modification to change from 60 to 400 cps power and to increase the amperage output of the regulated voltage to handle 3 instead of 2 rf units (microwave receivers or transmitters). Items 5 through 8 require minor modification to handle the requirements of the video and trigger signals. Items 13 and 14 require minor modification to enable operation with 1 and 10 speed antenna data in place of 1 and 36 speed data. Item 17 requires minor modification to add extra breakers for additional primary power branch circuits.

Items 24 through 27 are equipments required for transmission and reception of the dc analog voltages corresponding to the positions of the elevation and azimuth scan antennas of the precision approach radar. These items require development because no equipment is available to meet the specified accuracy requirements. The analog data transmitter and analog data receiver are the only two items that will require a great deal of development work.

Items 27 and 28 are required for transmission and reception of gate signals. These items require development because no equipment has been previously developed to transmit gate signals (with the required

rise and decay time) via microwave. The equipment is relatively simple and development will be no problem.

Item 33 is utilized to regenerate the beacon trigger. Equipment similar to this has been developed previously by Motorola but a small amount of additional development work is thought necessary. It is possible that a VT demultiplexer (Item 7) could be used in place of this item.

3.5.2 SEARCH RADAR AND IFF EQUIPMENT MODIFICATIONS

The following modifications required on the search radar or the IFF receiver for compatibility with the microwave equipment are based on the AN/TPS-35 radar. Control or signal source circuits will have to be modified as follows:

A. Antenna Azimuth Rotational Data

Two resolvers must be mounted in the radar antenna pedestal to provide one and ten-speed resolver data to the search microwave group. A resolver reference generator must be added to the radar equipment to provide resolver reference signals to the antenna resolvers and to the microwave group.

B. Normal IF Gain Control

The radar set must be modified to include the necessary relays, motor and potentiometer to enable the IF gain to be controlled by the output of a three state (ON-OFF-ON) VFC receiver to provide the following outputs.

	Circuit No. 1		Circuit No. 2	
Control State	Level	Source Impedance	Level	Source Impedance
ON	0 volts (gnd)	0 ohms	Open circuit	Infinite
OFF	Open Circuit	Infinite	Open circuit	Infinite
ON	Open Circuit	Infinite	0 volts (gnd)	0 ohms

Circuit No. 1 will control the rotation of the motor in one direction, and circuit No. 2 will control the rotation of the motor in the opposite direction. In the OFF condition, the motor will not be energized.

C. MTI IF Gain Control

MTI IF gain control requirements are the same as normal IF gain control.

D. STC Gain

STC gain control requirements are the same as normal IF gain control.

E. FTC IN-OUT Control

The radar set must be modified to include the necessary circuits to enable control of the FTC by the output of a two state (ON-OFF) VFC receiver that provides the following outputs.

Control State	Level	Source Impedance
IN	0 volts (gnd)	0 ohms
OUT	Open Circuit	Infinite

Only one circuit is needed since this is a simple ON-OFF function.

F. Circular Polarization IN-OUT Control

Circular polarization control requirements are the same as for FTC control.

G. Pulse Width Discrimination IN-OUT Control

Pulse width discrimination control requirements are the same as for FTC control.

H. STC IN-OUT Control

STC control requirements are the same as FTC control.

The IFF receiver modification will require that the wires to the gain control potentiometer be disconnected and routed to an external connector. This external connector will connect to a cable from the IFF gain control adapter which is utilized to enable control of the IFFgain via microwave (or cable). It may also be desirable that the modification

of the IFF receiver include a switch to enable switching from the gain control in the receiver to the remote gain control or vice versa when desired.

In order to control the Normal IF gain, MTI IF gain, STC gain, and IFF receiver gain via microwave, a control panel containing four three-position switches must be provided at the IFR control center. The output of each switch will be connected to the appropriate microwave control channel and the output must be the same as that of the VFC receiver for normal IF gain control (Item B, above). The switch will be nonlocking in the two ON positions and will return to the center (OFF) position when released. One ON position will drive the motor driven potentiometer (at the radar site) in a given direction and the other ON position will drive it in the opposite direction.

3.5.3 PRECISION APPROACH RADAR AND INDICATOR MODIFICATIONS

The following modifications required on the PAR and indicator for compatibility with the microwave equipment are based on the AN/TPN-14 radar. Control circuits will be required to be modified as follows.

A. Azimuth IF Gain Control Radar

The radar set must be modified to include the necessary relays, motor, and potentiometer to enable the azimuth IF gain to be controlled by the output of a three state (ON-OFF-ON) VFC receiver that provides the following outputs.

	Circuit No. 1		Circuit No. 2	
Control State	Level	Source Impedance	Level	Source Impedance
ON	0 volts (gnd)	0 ohms	Open Circuit	Infinite
OFF	Open Circuit	Infinite	Open Circuit	Infinite
ON	Open Circuit	Infinite	0 volts (gnd)	0 ohms

Circuit No. 1 will control the rotation of the motor in one direction, and circuit No. 2 will control the rotation of the motor in the opposite direction. In the OFF condition, the motor will not be energized.

B. Elevation IF Gain Control, Radar

Elevation IF gain control requirements for the radar are the same as azimuth IF gain control requirements for the radar.

C. Azimuth IF Gain Control, Indicator

The PAR indicator contains a potentiometer for controlling the IF gain of the radar set. Since a voltage corresponding to any desired position of the potentiometer cannot be easily transmitted via microwave, the potentiometer must be removed from the indicator and replaced by a three-position switch which can control via microwave a motor driven potentiometer in the radar set. The output of the three-position switch must be the same as listed for the VFC receiver for azimuth IF gain control (Item A, above). The switch will be nonlocking in the two ON positions and will return to the center (OFF) position when released.

D. Elevation IF Gain Control, Indicator

Elevation IF gain control requirements for the indicator are the same as azimuth IF gain control requirements for the indicator.

3.6 SUMMARY OF MICROWAVE WEIGHT AND POWER REQUIREMENTS

The total weight and power requirements of the microwave equipment (derived from Table 3-3) for each shelter is listed below.

Shelter Designation	Microwave Equipment Weight (lbs)	Microwave Equipment Amps*	Power Watts
Search radar shelter	920.8	14.7	2242
Precision approach radar (PAR) shelter	1006.9	18.3	2039
Instrument Flight Rules (IFR) shelter	1545.0	35.1	4118

*Assumes single phase 400 cps power source. Current would be equally divided for three phase source.

The above weights include the microwave antenna(s) and supports which total more than 350 pounds for each shelter. There seems to be considerable room for weight reduction here by using lighter materials. Not included in the above is the weight of the interconnecting cabling to associated radar equipment and between racks, nor the weight of the waveguide from the RF equipment to the antenna.

3.7 MICROWAVE EQUIPMENT UTILIZATION

The microwave equipment is utilized to form two single hop links, each consisting of two microwave terminals as follows:

Microwave Link Designation	Location of Terminals	Designation of Terminals
Search Microwave Link	Search Radar	Search Terminal
	IFR Control Center	IFR-Search Terminal
PAR Microwave Link	PAR (Precision Approach Radar)	PAR Terminal
	IFR Control Center	IFR-PAR Terminal

Each of the two microwave links consist of three microwave channels - two transmitted from the radar set to the control center, and one transmitted from the control center to the radar set. Each microwave channel will be utilized to remote radar data, and/or control signals, and/or voice communications. The designation and function of these channels are as shown in Table 3-4.

Table 3-4. Designation and function of microwave channels

Microwave Link Designation	Channel Designation	Direction of Transmission From	To	Functions Remoted
IFR-Search Link	No. 1	Search Radar	IFR Center	Normal video, MIT (special) video, System trigger, antenna azimuth data.
	No. 2	Search Radar	IFR Center	IFF raw video, radar pretrigger, order wire (voice) communications.
	No. 3	IFR Center	Search Radar	Beacon trigger, radar control signals, order wire (voice) communications.
IFR-PAR Link	A	PAR	IFR Center	Normal video, radar trigger.
	B	PAR	IFR Center	Azimuth and elevation antenna data, gate signals order wire (voice) communications.
	C	IFR Center	PAR	Radar control signals, order wire (voice) communications.

The channels for the IFR-Search link are designated by numbers and the channels for the IFR-PAR link are designated by letters. This procedure is employed to reduce the possibility of confusing the channels of the two microwave links. Confusion could occur at the control center because the equipment of both terminals is combined in common racks. The same procedure is also employed for the FM subcarrier channels and voice frequency carrier (or tone) channels. Equipment in the block diagrams and in the rack layout is also designated by the appropriate letters or numbers.

3.7.1 IFR-SEARCH MICROWAVE LINK EQUIPMENT UTILIZATION

The following tables designate the manner in which the equipment for the IFR-search microwave link is utilized to meet the remoting requirements of the search radar. All microwave, subcarrier, and VFC channels are designated by numbers. The multiplex equipment is listed following the microwave receiver or transmitter with which it is associated. Power supplies and power distribution panels are not listed since they are not directly associated with signals.

Table 3-5. Search terminal, equipment utilization

Equipment	Designation	Associated Signal(s)
Microwave Transmitter	MW XMTR CH 1	Composite video, trigger and azimuth signals.
Subcarrier Transmitter	S. C. CH 1	Resolver reference
Subcarrier Transmitter	S. C. CH 2	Resolver coarse (IX)
Subcarrier Transmitter	S. C. CH 3	Resolver fine (10X)
Video, Video and Trigger Multiplexer	VVT MUX	Normal video, MTI (special) video, system trigger
Microwave Transmitter	MW XMTR CH 2	Composite beacon video, pre-trigger and order wire signals.
Video and Trigger Multiplexer	VT MUX	Pre-trigger, beacon video
Order wire (transmitter)	ORDER WIRE	Voice Communications
Microwave Receiver	MW CH 3	Composite beacon trigger, control, and order wire signals.
Trigger Generator	TRIGGER GENERATOR	Beacon Trigger
Subcarrier Receiver	S. C. CH 4	Composite VFC signals.
Voice Frequency Carrier Receiver	VFC RCVR CH1	Normal IF Gain Control (3 state)
Voice Frequency Carrier Receiver	VFC RCVR CH2	MTI IF Gain Control (3 state)
Voice Frequency Carrier Receiver	VFC RCVR CH3	Beacon (IFF) Receiver Gain Control (3 state)
Voice Frequency Carrier Receiver	VFC RCVR CH4	STC Gain Control (3 state)
Voice Frequency Carrier Receiver	VFC RCVR CH5	FTC IN-OUT Control (2 state)

Table 3-5. Search terminal, equipment utilization (continued)

Equipment	Designation	Associated Signal(s)
Voice Frequency Carrier Receiver	VFC RCVR CH6	Circular Polarization IN-OUT Control (2 state)
Voice Frequency Carrier Receiver	VFC RCVR CH7	Pulse width discriminator IN-OUT Control (2 state)
Voice Frequency Carrier Receiver	VFC RCVR CH8	STC IN-OUT Control (2 state)
Voice Frequency Carrier Receiver	VFC RCVR CH9	Noise receiver. Protects other VFC receiver from false operation during a microwave signal fade.
Order Wire (receiver)	ORDER WIRE	Voice Communications
Monitor Panel	MONITOR PANEL	Composite video signals to microwave transmitters or from microwave receiver.
Precision Variable Attenuator	VARIABLE ATTENUATOR	All RF signals from transmitters or to receiver. Is used for determining signal strength margin.
IFF Gain Control Adapter	Same as Equipment	IFF receiver gain control (output of VFC RCVR CH 3)

Table 3-6. IFR-search terminal, equipment utilization

Equipment	Designation	Associated Signal(s)
Microwave Receiver	MW RCVR CH 1	Composite video trigger and azimuth signals.
Subcarrier Receiver	S.C. RCVR CH 1	Resolver coarse (1-X)
Subcarrier Receiver	S.C. RCVR CH 2	Resolver fine (10X)
Subcarrier Receiver	S.C. RCVR CH 3	Resolver reference
Electronic Control Amplifier	ELECTRONIC CONTROL AMPL	Reference, coarse, and fine resolver signal inputs. Error signal to synchro assembly.
Synchro Assembly	SYNCHRO ASSEMBLY	One speed synchro data output.
Video, video, and Trigger Demultiplexer	VVT DEMUX	Normal video, MTI (special) video, system trigger
Microwave Receiver	MW RCVR CH 2	Composite beacon video, pre-trigger and order wire signals.
Video and Trigger Demultiplexer	VT DEMUX	Pre-trigger and beacon (IFF) video.
Order Wire (Receiver)	ORDER WIRE	Voice Communications
Microwave Transmitter	MW XMTR CH 3	Composite beacon trigger, control, and order wire signals.
Video and Trigger Multiplexer	VT MUX	Beacon Trigger
Subcarrier Transmitter	S.C. XMTR CH 4	Combined VFC (tone control) signals.
Voice Frequency (Tone) Transmitter	VFC XMTR CH 1	Normal IF gain control (3 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH 2	MTI IF gain control (3 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH 3	Beacon (IFF) Receiver Gain control (3 state)

Table 3-6. IFR-search terminal, equipment utilization (continued)

Equipment	Designation	Associated Signal(s)
Voice Frequency (Tone) Transmitter	VFC XMTR CH 4	STC Gain Control (3 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH 5	FTC IN-OUT Control (2 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH 6	Circular Polarization IN-OUT control (2 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH 7	Pulse Width Discriminator IN-OUT control (2 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH 8	STC IN-OUT control (2 state)
Order Wire (Transmitter)	ORDER WIRE	Voice Communications
Monitor Panel	MONITOR PANEL	Composite video signals to microwave transmitter or from microwave receivers.

3.7.2 IFR-PAR MICROWAVE LINK EQUIPMENT UTILIZATION

The following tables designate the manner in which the equipment for the IFR-PAR microwave link is utilized to meet the remoting requirements of the precision approach radar. All microwave, subcarrier, and VFC channels are designated by letters. The multiplex equipment is listed following the microwave receiver or transmitter with which it is associated. Power supplies and power distribution panels are not listed since they are not directly associated with signals.

Table 3-7. PAR terminal, equipment utilization

Equipment	Designation	Associated Signal(s)
Microwave Transmitter	MW XMTR CH A	Composite video and trigger signals.
Video and Trigger Multiplexer	VT MUX	Normal video, radar trigger
Microwave Transmitter	MW XMTR CH B	Composite azimuth, elevation, gate, control and order wire signals
Subcarrier Transmitter	S.C. XMTR CH A	Azimuth scan position of azimuth scan antenna
Analog Data Transmitter	AD XMTR A	Same as above
Subcarrier Transmitter	S.C. XMTR CH B	Elevation (tilt) position of azimuth scan antenna
Analog Data Transmitter	AD XMTR B	Same as above
Subcarrier Transmitter	S.C. XMTR CH C	Elevation scan position of elevation scan antenna
Analog Data Transmitter	AD XMTR C	Same as above
Subcarrier Transmitter	S.C. XMTR CH D	Azimuth position of elevation scan antenna
Analog Data Transmitter	AD XMTR D	Same as above
Subcarrier Transmitter	S.C. XMTR CH E	Unblanking gate
Subcarrier Transmitter	S.C. XMTR CH F	Relay gate
Gate Signal Converter	GATE SIGNAL CONVERTER	Unblanking gate and relay gate
Order Wire (Transmitter)	ORDER WIRE	Voice Communications
Subcarrier Transmitter	S.C. XMTR CH G	H.V. ON-OFF readback
Voice Frequency Carrier (Tone) Transmitter	VFC XMTR CH L	Same as above

Table 3-7. **PAR terminal, equipment utilization (continued)**

Equipment	Designation	Associated Signal(s)
Microwave Receiver	MW RCVR CH C	Composite VFC and order wire signals
Subcarrier Receiver	S.C. RCVR CH H	Composite VFC (Tone control) signals
Voice Frequency Carrier Receiver	VFC RCVR CH A	Azimuth IF gain control (3 state)
Voice Frequency Carrier Receiver	VFC RCVR CH B	Elevation IF gain control (3 state)
Voice Frequency Carrier Receiver	VFC RCVR CH C	Azimuth scan elevation (tilt) control (3 state)
Voice Frequency Carrier Receiver	VFC RCVR CH D	Elevation-scan azimuth control (3 state)
Voice Frequency Carrier Receiver	VFC RCVR CH E	High Voltage ON-OFF control (2 state)
Voice Frequency Carrier Receiver	VFC RCVR CH F	Elevation scan mode (2 state)
Voice Frequency Carrier Receiver	VFC RCVR CH G	Azimuth scan mode (2 state)
Voice Frequency Carrier Receiver	VFC RCVR CH H	FTC ON-OFF (2 state)
Voice Frequency Carrier Receiver	VFC RCVR CH J	STC ON-OFF (2 state)
Voice Frequency Carrier Receiver	VFC RCVR CH K	Antenna Scan ON-OFF control (2 state)
Voice Frequency Carrier Receiver	VFC RCVR CH M	Noise receiver; protects other VFC receivers from false operation during a microwave signal fade.

Table 3-7. PAR terminal, equipment utilization (continued)

Equipment	Designation	Associated Signal(s)
Order Wire (Receiver)	ORDER WIRE	Voice Communications
Monitor Panel	MONITOR PANEL	Composite video signals to microwave transmitters or from microwave receiver
Precision Variable Attenuator	VARIABLE ATTENUATOR	All RF signals to or from microwave receiver or transmitters. Used for determining signal strength margin.

Table 3-8. IFR-PAR terminal, equipment utilization

Equipment	Designation	Associated Signal(s)
Microwave Receiver	MW RCVR CH A	Composite video and trigger signals (PAR).
Video and Trigger Demultiplexer	VT DEMUX	Normal Video, Trigger
Microwave Receiver	MW RCVR CH B	Composite subcarrier channels carrying antenna azimuth and elevation data, gate signals, and order wire communications
Subcarrier Receiver	S.C. RCVR CH A	Azimuth position of azimuth scan antenna
Analog Data Receiver	AD RCVR A	Same as above
Subcarrier Receiver	S.C. RCVR CH B	Elevation (tilt) position of azimuth scan antenna
Analog Data Receiver	AD RCVR B	Same as above
Subcarrier Receiver	S.C. RCVR CH C	Elevation position of elevation scan antenna
Analog Data Receiver	AD RCVR C	Same as above
Subcarrier Receiver	S.C. RCVR CH D	Azimuth position of elevation scan antenna
Analog Data Receiver	AD RCVR D	Same as above
Subcarrier Receiver	S.C. RCVR CH E	Unblanking Gate
Subcarrier Receiver	S.C. RCVR CH F	Relay Gate
Gate Generator	GATE GENERATOR	Unblanking Gate and Relay Gate
Subcarrier Receiver	S.C. RCVR CH G	H.V. ON-OFF Readback
Voice Frequency Receiver	VFC RCVR CH L	Same as above
Voice Frequency Receiver	VFC RCVR CH M	Noise receiver. Protects other VFC receivers from false operation during a microwave signal fade.

Table 3-8. IFR-PAR terminal, equipment utilization (continued)

Equipment	Designation	Associated Signal(s)
Order Wire (receiver)	ORDER WIRE	Voice Communication
—	—	—
Microwave Transmitter	MW XMTR CH C	Composite VFC (Tone Control) and order wire signals
Subcarrier Transmitter	S.C. XMTR CH H	Combined VFC (Tone Control) signals
Voice Frequency (Tone) Transmitter	VFC XMTR CH A	Azimuth IF Gain Control (3 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH B	Elevation IF Gain Control (3 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH C	Azimuth Scan Elevation (tilt) control (3 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH D	Elevation Scan Azimuth control (3 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH E	High Voltage ON-OFF control (3 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH F	Elevation Scan Mode (2 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH G	Azimuth Scan Mode (2 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH H	FTC ON-OFF (2 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH J	STC ON-OFF (2 state)
Voice Frequency (Tone) Transmitter	VFC XMTR CH K	Antenna Scan ON-OFF control (2 state)
Order Wire (Transmitter)	ORDER WIRE	Voice Communications
—	—	—
Monitor Panel	MONITOR PANEL	Composite video signals to microwave transmitter or from microwave receivers

3.8 BLOCK DIAGRAMS AND DISCUSSION

The block diagrams of the IFR-Search microwave link and the IFR-PAR microwave link are shown in Figures 3-1 and 3-2 respectively. Each block diagram shows the complete microwave link rather than the individual shelter installations in order to provide a more complete picture of the function of the microwave remoting system. Also shown are the associated junction boxes, radar, control, and indicating equipment. Since remoting via either cable or microwave is required, the cable connection between shelters to the microwave-cable junction boxes is shown. The junction box routes the signals to or from the remoting cable or the microwave, depending upon which mode of operation is employed. It should be remembered that both microwave links have terminals at the IFR control center and both of these terminals are contained in common racks and also share some common items of equipment.

3.8.1 IFR-SEARCH MICROWAVE LINK

The IFR-Search Microwave Link remotes the functions of the search radar over radio line-of-sight distances up to 15 miles. The microwave link block diagram will be discussed according to the signals transmitted over the individual microwave channels. All microwave, subcarrier, and VFC channels are designated by numbers.

A. Microwave Channel Number 1

Microwave Channel No. 1 is used to remote antenna azimuth data, normal video, MTI (special) video and system trigger which originate at the search radar. The antenna azimuth data

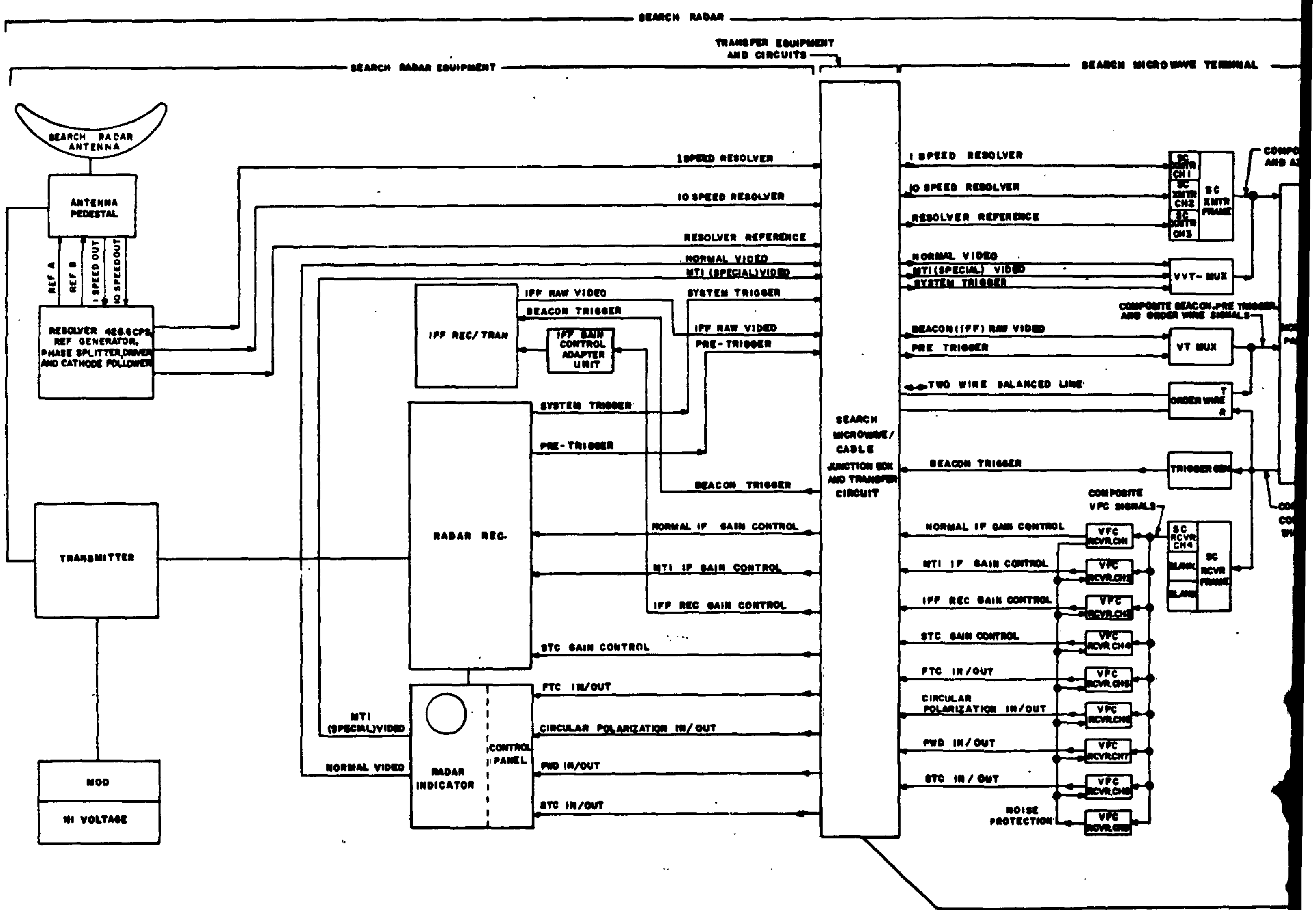


Figure 3-1. IFR-search microwave/cable link and associated equipment

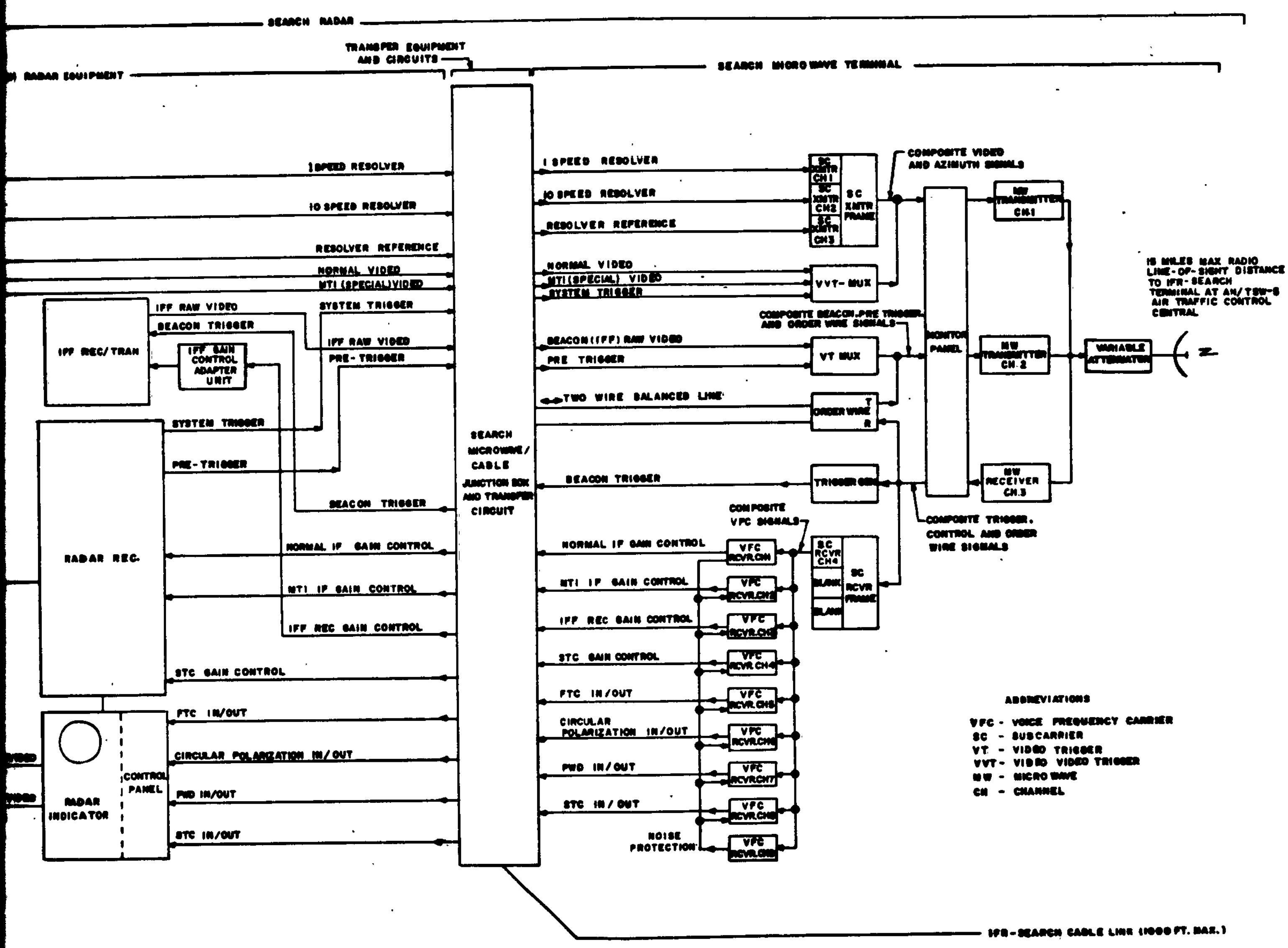


Figure 3-1. IFR-search microwave/cable link and associated equipment

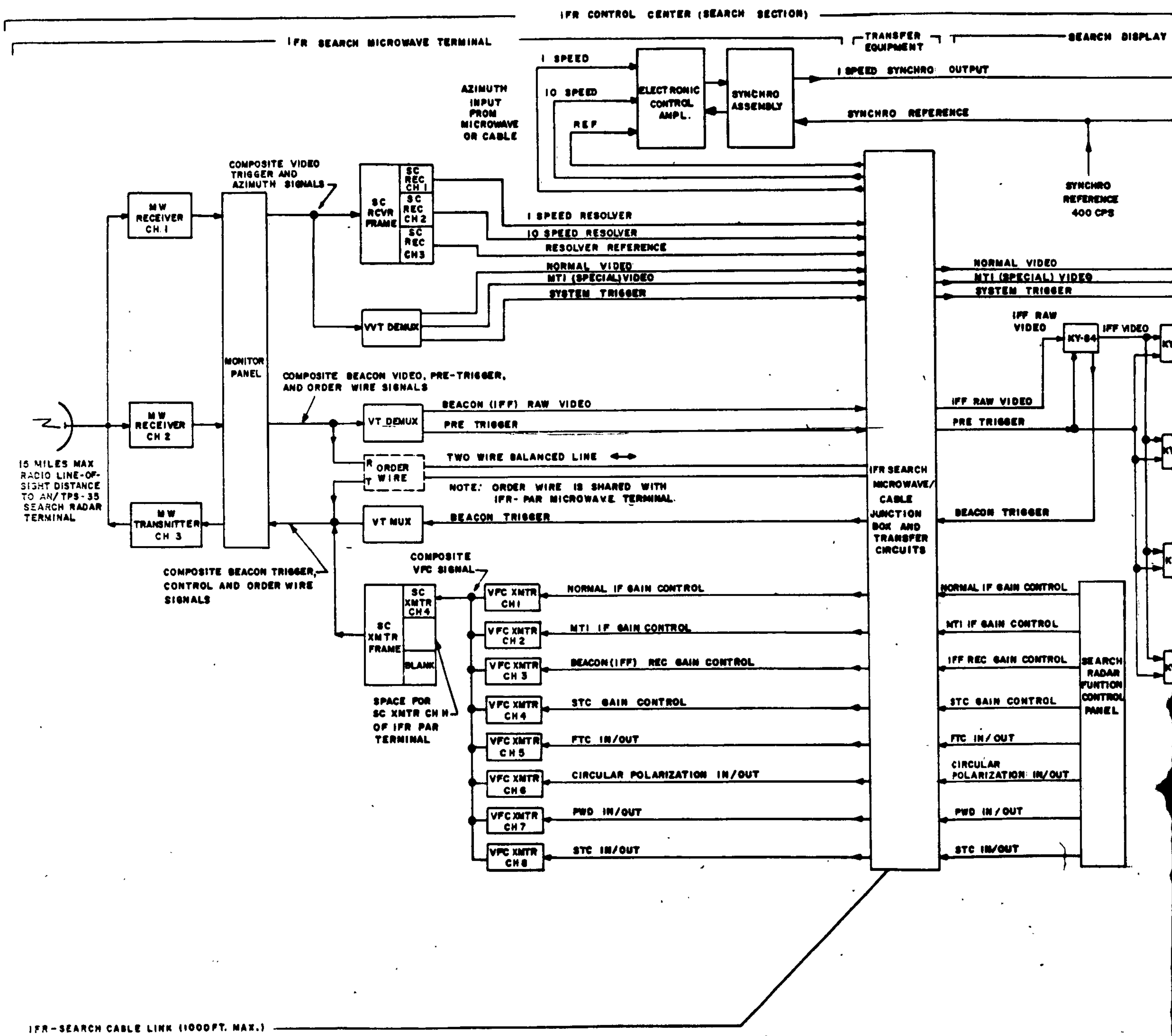


Figure 3-1 IFR-search microwave/cable link and associated equipment

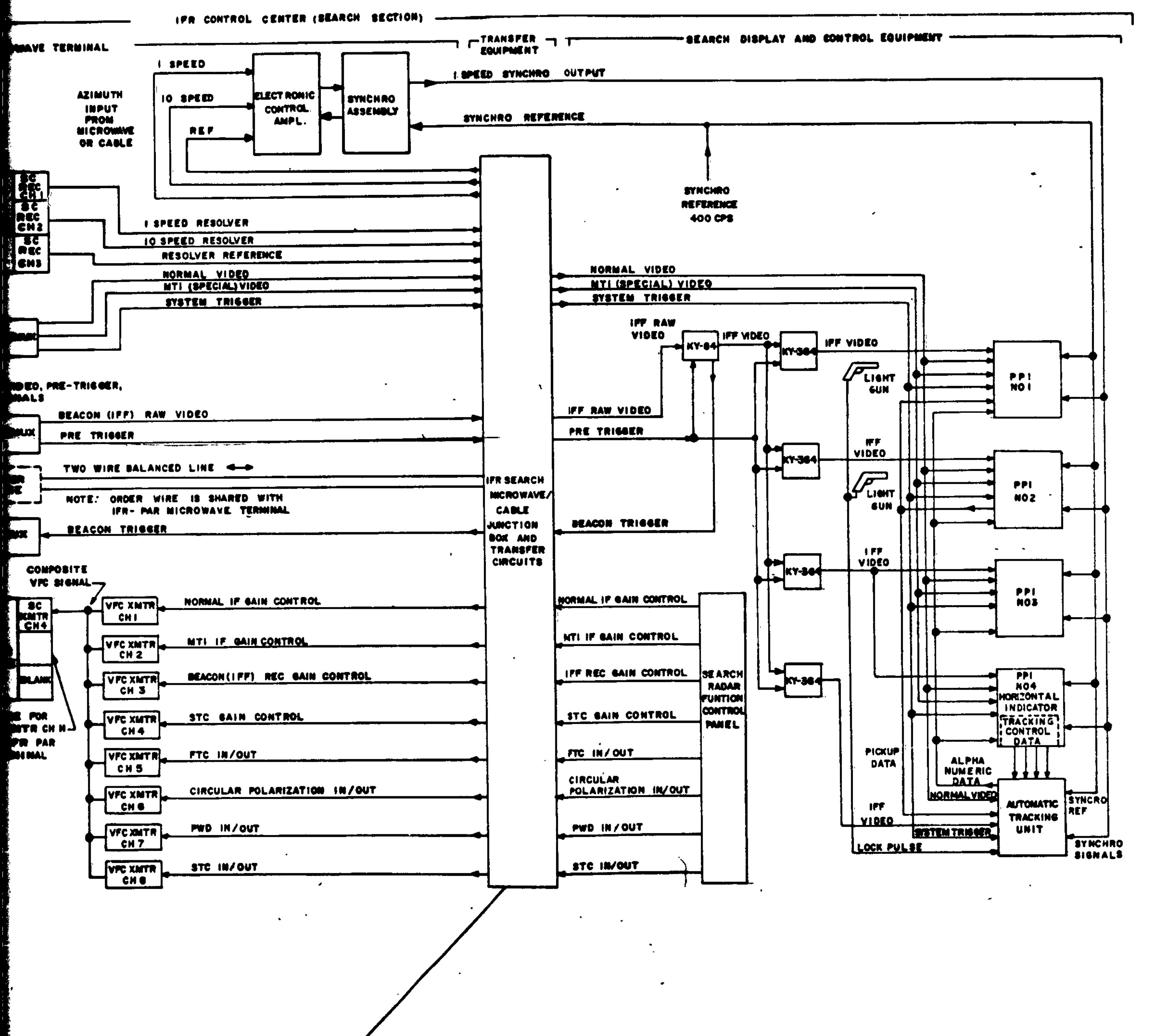


Figure 3-1 IFR-search microwave/cable link and associated equipment

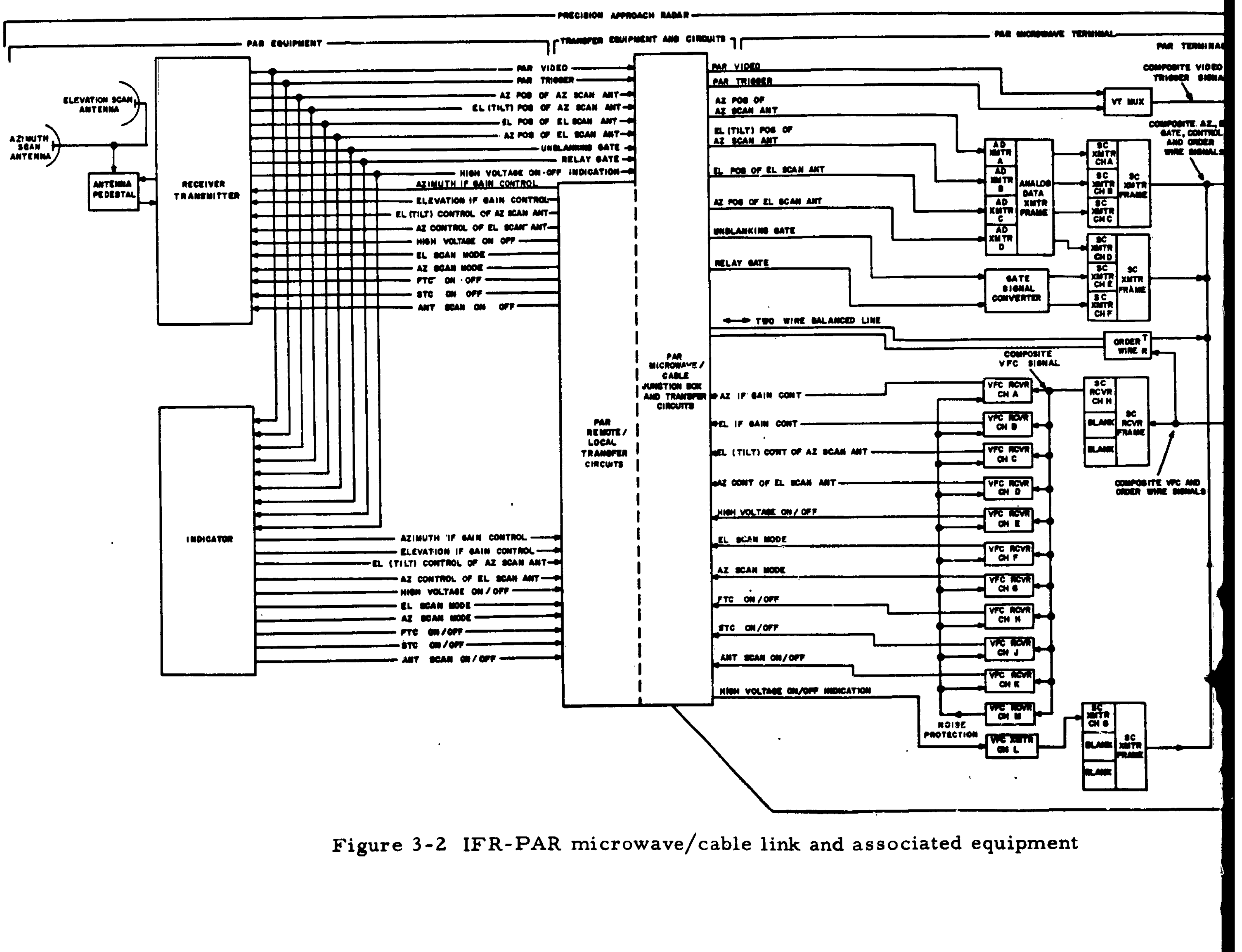


Figure 3-2 IFR-PAR microwave/cable link and associated equipment

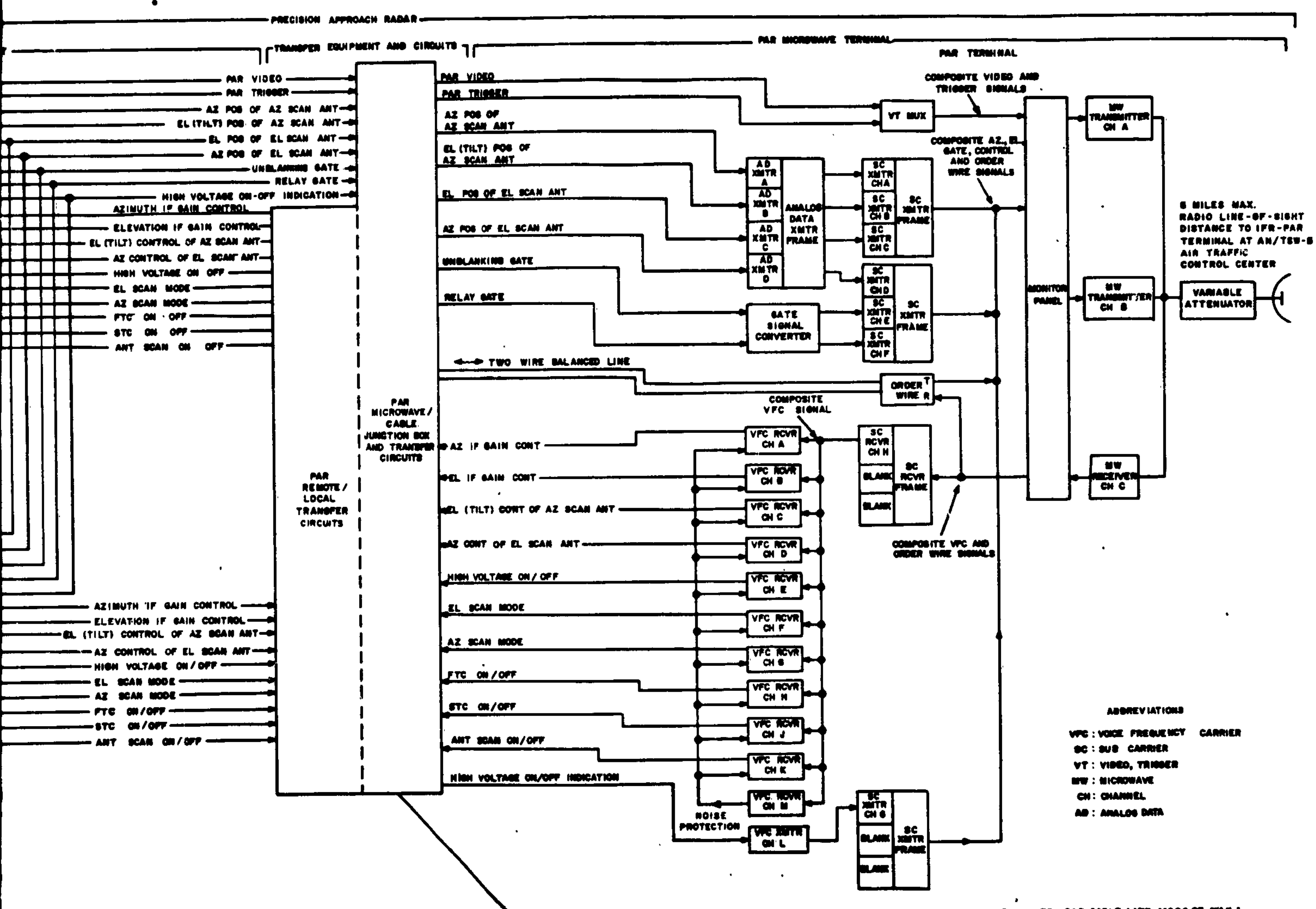


Figure 3-2 IFR-PAR microwave/cable link and associated equipment

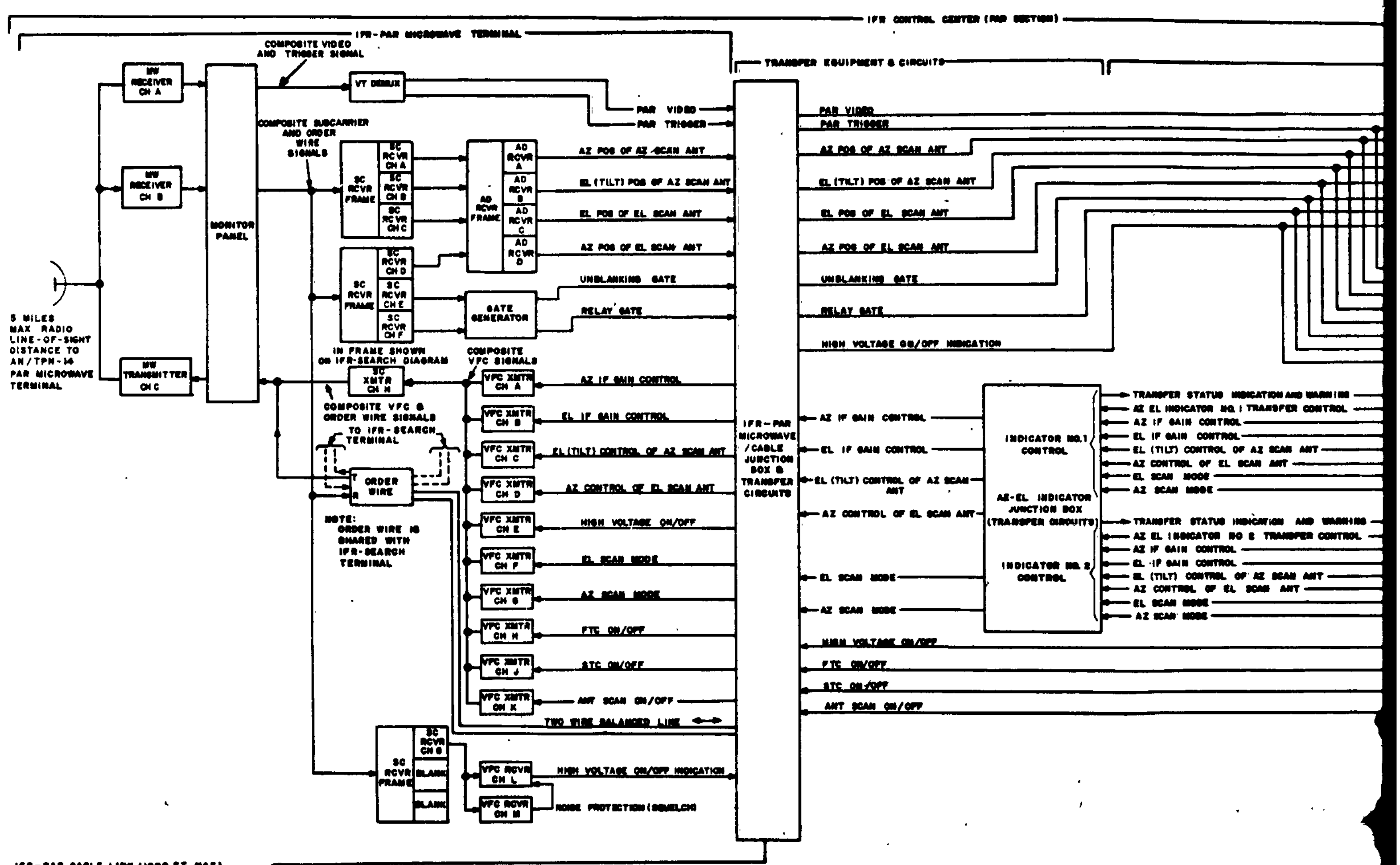
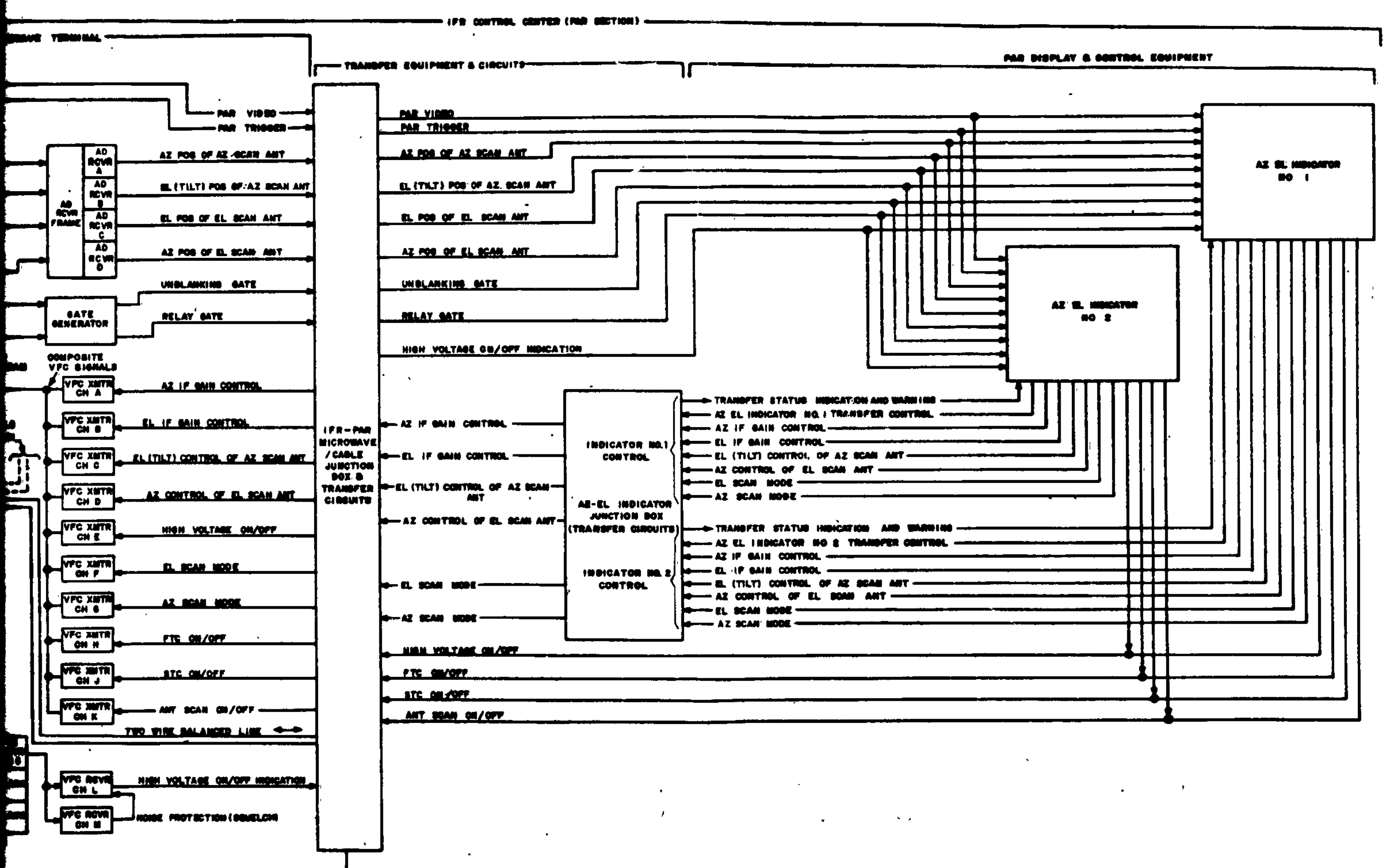


Figure 3-2 IFR-PAR microwave/cable link and associated equipment



'igure 3-2 IFR-PAR microwave/cable link and associated equipment

is obtained from the radar in the form of three resolver signals, coarse, fine, and reference. All resolver signals are 426.6 cps sine waves, and the fine and coarse signals are shifted in phase relative to the reference according to the azimuth position of the radar antenna. These three signals go to the cable/microwave junction box in which they are routed to the three subcarrier transmitters for subcarrier channels 1, 2, and 3. The sub-carrier transmitters are frequency modulated by the resolver tones, and the outputs of the S.C. transmitters are combined with the VVT multiplexer output to modulate the channel 1 microwave transmitter. The normal video, MTI (special) video and system trigger are obtained from the radar indicator and radar receiver and go to the junction box in which they are routed to the VVT multiplexer where the normal video and trigger are combined to form a bipolar signal and the MTI video modulates a subcarrier which is combined with the bipolar signal to give a single output signal. The output of the VVT multiplexer is combined with the outputs of the three subcarrier transmitters for modulation of channel 1 microwave transmitter. The composite video signal is routed through the monitor panel before being applied to channel 1 transmitter. The transmitter is also modulated by an internal 7.0 Mc alarm transmitter. Figure 3-3A shows how the various signals are combined on channel 1 video baseband. The output of the transmitter is applied to a common waveguide which goes to the antenna. The variable attenuator in the waveguide is used for determining fade margin and is normally set to zero.

At the IFR control center, the microwave antenna for the IFR-search terminal picks up the channel 1 microwave signal which is routed via a common waveguide to channel 1 microwave receiver. The receiver demodulates the signal which is then routed via the

monitor panel to channels 1, 2, and 3 subcarrier receivers and the VVT demultiplexer. The subcarrier receivers separate the respective subcarrier signals, amplify and demodulate them and provide resolver coarse, fine, and reference outputs. The three resolver signals then go to microwave/cable junction box from which they are routed to the electronic control amplifier which generates error signals to control the synchro assembly. The synchro assembly provides 1 speed synchro output which corresponds to the azimuth position of the search radar antenna. The synchro output is applied to the PPI indicators and the automatic tracking unit.

It should be noted that the electronic control amplifier and synchro assembly will also operate with resolver signals received via cable. When operating via cable, these items are independent of the remainder of the microwave equipment.

The VVT demultiplexer filters the bipolar video from channel 1 composite video signal and provides separate normal video and trigger outputs. It also separates and demodulates the modulated carrier containing MTI video and provides this at a separate output. These three signals then go to the junction box where they are routed to the PPI indicators and the automatic tracking unit.

B. Microwave Channel Number 2

Microwave Channel Number 2 is used to remote IFF video, pre-trigger, and order wire (voice) communications which originate at the search radar. The IFF video is obtained from the IFF receiver and the pre-trigger is obtained from the radar receiver. These two signals go to the junction box from which they are routed to the VT multiplexer. The VT multiplexer combines the IFF video and pre-trigger into a composite bipolar signal. The

order wire unit has a microphone input which is used to frequency modulate the order wire transmitter. The outputs of the VT multiplexer and the order wire transmitter are combined to form a composite video signal which is routed through the monitor panel and used to modulate channel 2 microwave transmitter. The transmitter is also modulated by a 7.0 Mc alarm transmitter. Figure 3-3B shows how the various signals are combined on channel 2 video baseband. The output is applied to the common waveguide to the microwave antenna.

At the IFR control center, the microwave antenna for the IFR-search terminal picks up the channel 2 microwave signal which is routed via the common waveguide to channel 2 microwave receiver. The receiver demodulates the signal which is then routed via the monitor panel to the VT demultiplexer and the order wire unit. The VT demultiplexer filters the bipolar video from channel 2 composite video signal and provides separate IFF video and pre-trigger outputs which are routed through the microwave/cable junction box to the IFF equipment. The order wire receiver separates the fm order wire signal from the composite video, demodulates it, and provides an audible output from a self contained speaker. The 7.0 Mc alarm signal is monitored by an alarm receiver included in the microwave receiver. If the alarm signal is lost due to channel failure or if channel noise becomes excessive, an alarm will be initiated.

Microwave Channel Number 3 is used to remote order wire, beacon (IFF) trigger, and search radar control signals which originate at the IFR control center. The beacon trigger originates at the coder-synchronizer and is routed through the junction box to the VT multiplexer, the video portion of which is used as an impedance matching and level control device, and the output is combined with the order wire and subcarrier signals. The voice input to the order

wire originates from an attached microphone, and the fm output of the order wire transmitter is combined with the beacon trigger and subcarrier signals. The eight control signals originate at the search radar function control panel. Each of the control signals is routed through the microwave/cable junction box to separate VFC (tone) transmitters, channels 1 through 8. Each VFC transmitter generates a tone which is frequency shift keyed according to the control input. All VFC transmitter channels are on different frequency bands, and the outputs are combined and used to modulate subcarrier transmitter, channel 4. The subcarrier output is combined with the beacon trigger and order wire signals and the resulting composite video signal is routed through the monitor panel to channel 3 microwave transmitter. The transmitter is modulated by the composite video signal and an internal 7.0 Mc alarm transmitter. Figure 3-3C shows how the various signals are combined on channel 3 video baseband. The output of the transmitter is applied to a common waveguide which goes to the IFR-search terminal microwave antenna.

At the search radar terminal the microwave antenna picks up the channel 3 microwave signal which is routed via the common waveguide to channel 3 microwave receiver. The composite video output of the receiver is routed through the monitor panel to the order wire, trigger generator, and subcarrier receiver channel 4.

The order wire receiver separates its assigned frequency from the composite video, demodulates it, and provides an audible output from a self contained speaker. The trigger generator filters the beacon trigger signal from the composite video and regenerates the beacon trigger which is routed via the junction box to the IFF transmitter. The receiver for subcarrier channel 4 separates the fm subcarrier signal from the composite video and provides an output

which consists of the eight combined VFC (tone) signals. The combined VFC signals are applied to VFC receivers, channels 1 through 9. VFC receivers 1 through 8 separate their respective tones and control signals and provide outputs in the form of contact closures. The control signals are either two state or three state signals. Two state signals provide ON-OFF control and three state signals provide ON-OFF-ON control for slewing motor driven gain control pots. All control signals go via the junction box directly to the radar set except for the IFF gain control which goes to an adapter containing a motor driven potentiometer for control of the IFF receiver gain. Channel 9 VFC receiver monitors noise on the subcarrier output and prevents false operation of the controls if the noise becomes excessive.

3.8.2 IFR-PAR MICROWAVE LINK

The IFR-PAR microwave link remotes the functions of the precision approach radar over radio line-of-sight distances up to 5 miles. The microwave link block diagram will be discussed according to the signals transmitted over the individual microwave channels. All microwave, subcarrier and VFC channels are designated by letters.

A. <u>Microwave Channel A</u>

Microwave channel A is used to remote radar video and trigger which originate at the PAR. Video and trigger are obtained from the receiver-transmitter unit, and are routed through the microwave/cable junction box to the VT multiplexer where they are combined into a composite bipolar signal which is routed through the monitor panel to channel A microwave transmitter. The transmitter is modulated by the composite video and an internal 7.0 Mc alarm transmitter. Figure 3-4A shows how the various signals are combined on channel A video baseband. The transmitter is frequency modulated and the

output goes through a common waveguide and variable attenuator to the microwave antenna.

At the IFR control center, the microwave antenna for the IFR-PAR terminal picks up the channel A microwave signal which is routed via a common waveguide to the channel A microwave receiver. The signal is amplified and demodulated and the composite video output is routed via the monitor panel to the VT demultiplexer which provides separate video and trigger outputs. The video and trigger are then routed through the microwave/cable junction box and to the azimuth-elevation indicators.

B. Microwave Channel B

Microwave channel B is used to remote azimuth and elevation antenna position, gate signals, order wire communications, and a control signal. The azimuth and elevation antenna positions in the form of continuously variable dc voltages are obtained from the radar set and routed through the junction box to analog data (AD) transmitters A through D. The analog data transmitters convert the dc voltages into signals suitable for transmission via subcarrier channels. The AD transmitter outputs modulate channels A through D subcarrier transmitters. The two gate signals in the form of switched dc levels are obtained from the receiver-transmitter, routed through the junction box and applied to the gate signal converter in which they are converted into a form suitable for transmission via subcarrier transmitters.

The voice input to the order wire originates from an attached microphone and the transmitter provides an fm output signal. The control signal (high voltage ON-OFF) originates at the receiver-transmitter and is routed through the junction box to VFC transmitter channel L where it is converted to a fsk tone which is applied to subcarrier transmitter, channel G, which in turn provides an fm subcarrier

output. The outputs of subcarrier transmitters A through G and the order wire are combined and routed through the monitor panel to channel B microwave transmitter. The transmitter is modulated by the combined signals and an internal 7.0 Mc alarm transmitter. Figure 3-4B shows how the various signals are combined on channel B video baseband. The transmitter is frequency modulated and the output goes through a common waveguide and variable attenuator to the microwave antenna.

At the IFR control center, the microwave antenna for the IFR-PAR terminal picks up the channel B microwave signal which is routed via the common waveguide to the channel B microwave receiver. The signal is amplified and demodulated and the composite video output is routed via the monitor panel to channels A through G subcarrier receivers, and the order wire unit. Subcarrier receivers A through D demodulate the signals on their assigned frequencies and the outputs are applied to analog data receivers A through D respectively. The outputs of the analog data receivers are the dc voltages representing the azimuth and elevation antenna positions. These dc voltages are routed through the junction box to the azimuth-elevation indicators.

Subcarrier receivers E and F demodulate the signals on their assigned frequencies and the outputs are applied to the gate generator which regenerates the original gate signals. The gate signals are routed through the junction box to the azimuth elevation indicators. Subcarrier receiver G demodulates the signal on its assigned frequency and the output consists of a fsk tone which is applied to VFC receiver channel L, the output of which is a two state control signal (high voltage ON-OFF indication). The control signal is routed via the junction box to the azimuth elevation indicators. VFC receiver channel M monitors noise on subcarrier channel G and prevents false operation of channel L VFC receiver control output when the

noise is excessive. The order wire receiver demodulates the signal on its assigned frequency and provides an audible output from a self-contained speaker.

C. Microwave Channel C

Microwave channel C is used to remote order wire communications and radar control signals which originate at the IFR control center. Voice input to the order wire originates from an attached microphone which modulates the order wire transmitter to give an fm output signal. All of the 10 control signals are obtained from the azimuth-elevation indicators from which six are routed via the az.-el. junction box and four are routed directly to the microwave/cable junction box. From the microwave/cable junction box, each of the ten control signals are applied to separate VFC (tone) transmitters. The output of VFC transmitters are fsk tones on different frequency bands. The tones are combined and applied to channel H subcarrier transmitter, the output of which is combined with the order wire signal routed via the monitor panel to channel C microwave transmitter. The transmitter is modulated by the combined signals and an internal 7.0 Mc alarm transmitter. Figure 3-4C shows how the various signals are combined on channel C video baseband. The frequency modulated output of the transmitter goes through a common waveguide to the microwave antenna for the IFR-PAR microwave terminal.

At the precision approach radar, the microwave antenna picks up the channel C microwave signal which is routed via the common waveguide to the channel C microwave receiver. The signal is amplified and demodulated and the composite video output is routed via the monitor panel to the order wire receiver and channel H subcarrier receiver. The order wire demodulates the signal on its assigned frequency providing an audio output from a self-contained speaker.

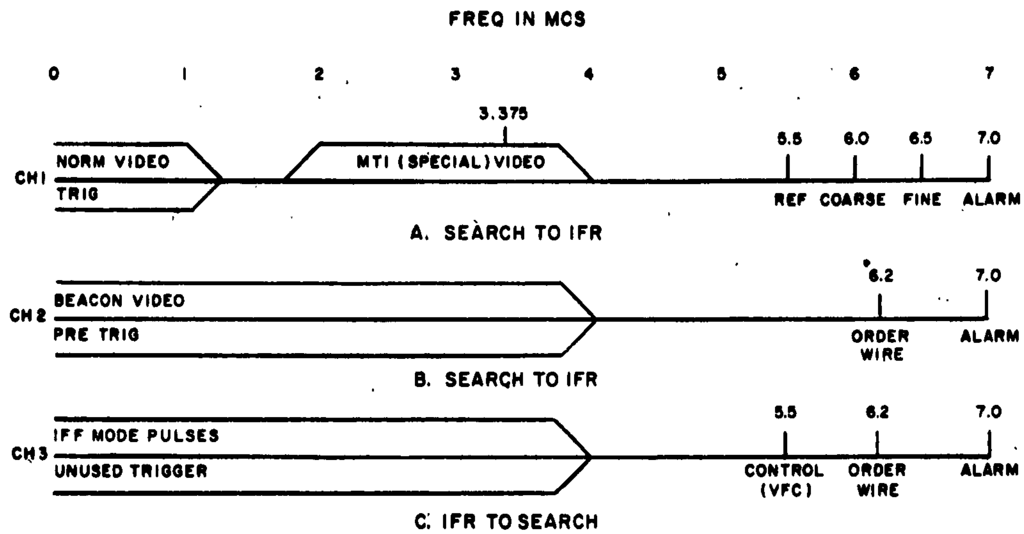


Figure 3-3. IFR-search microwave link, baseband usage

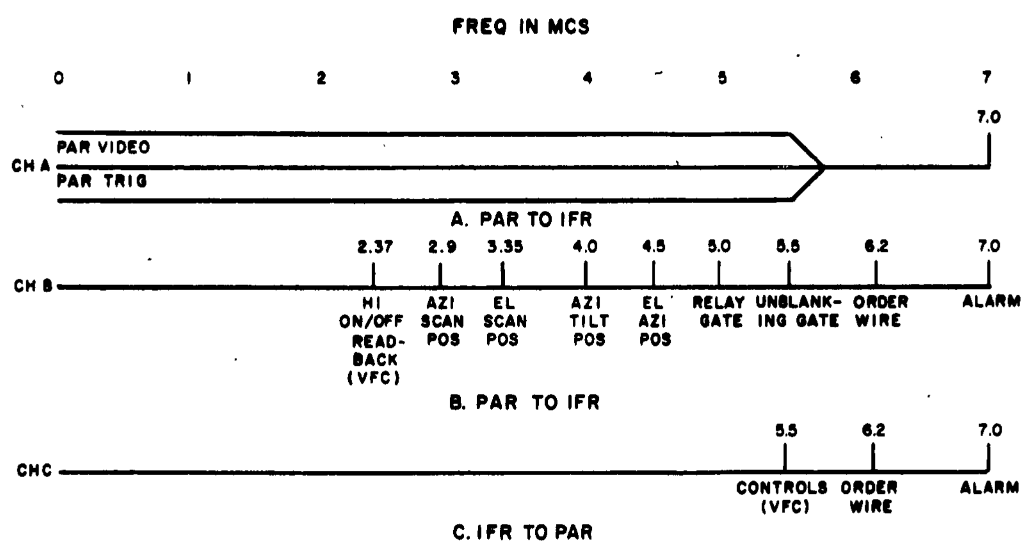


Figure 3-4. IFR-PAR microwave link, baseband usage

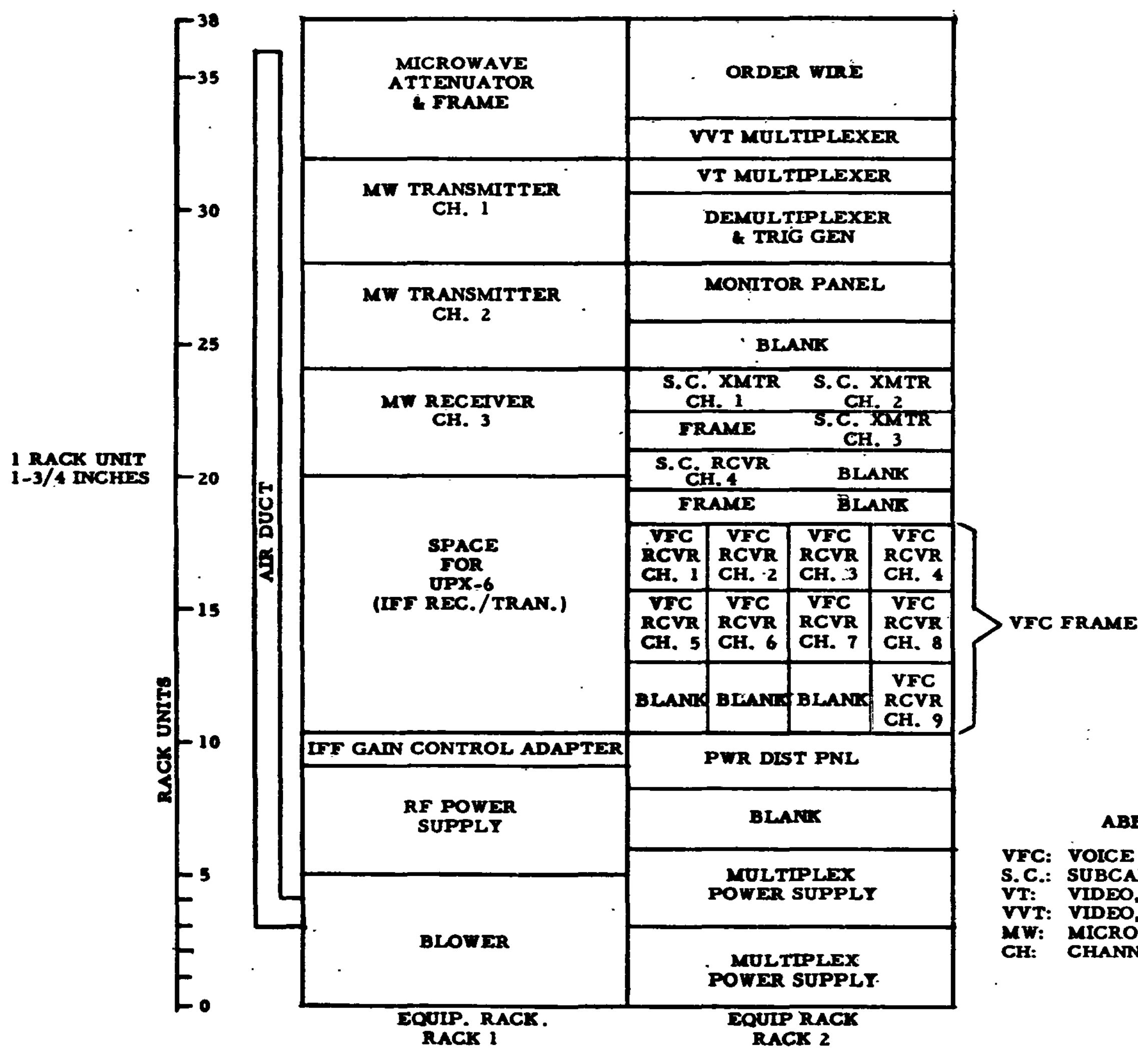
Channel H subcarrier receiver demodulates the signal on its assigned frequency and provides an output consisting of the combined VFC tones. The combined VFC signals are applied to VFC receivers A through K, each of which demodulates the tone signals in its assigned band and provides control outputs which are routed through the microwave/cable junction box and the remote/local transfer circuits to the radar set. The 7.0 Mc alarm signal is monitored by an alarm receiver included in the microwave receiver. If the alarm signal is lost due to channel failure or if channel noise becomes excessive an alarm will be initiated.

3.9 EQUIPMENT LAYOUT AND DESCRIPTION OF MICROWAVE TERMINALS

The following paragraphs discuss the equipment layout at each of the microwave groups. All equipment is mounted in 19-inch racks which pivot on the left side and rotate at least 90 degrees about a vertical axis to allow maintenance to be performed on the equipment from the rear of the rack. The racks are mounted on shocks attached to the ceiling and floor of the shelter. The figures showing the equipment layout (front view) do not show the racks or the required spacing between the racks. The spacing between racks or other obstructions must be adequate to allow clearance by the microwave equipment when the rack is rotated.

3.9.1 SEARCH MICROWAVE TERMINAL LAYOUT

The suggested rack layout of the search microwave terminal is shown in Figure 3-5. The equipment is contained in two racks. Profile views of Racks 1 and 2 are shown in Figures 3-6 and 3-7 respectively.



ABBREVIATIONS

VFC: VOICE FREQUENCY CARRIER
S.C.: SUBCARRIER
VT: VIDEO, TRIGGER
VVT: VIDEO, VIDEO, TRIGGER
MW: MICROWAVE
CH: CHANNEL

Figure 3-5. Search Microwave Terminal, Equipment Layout

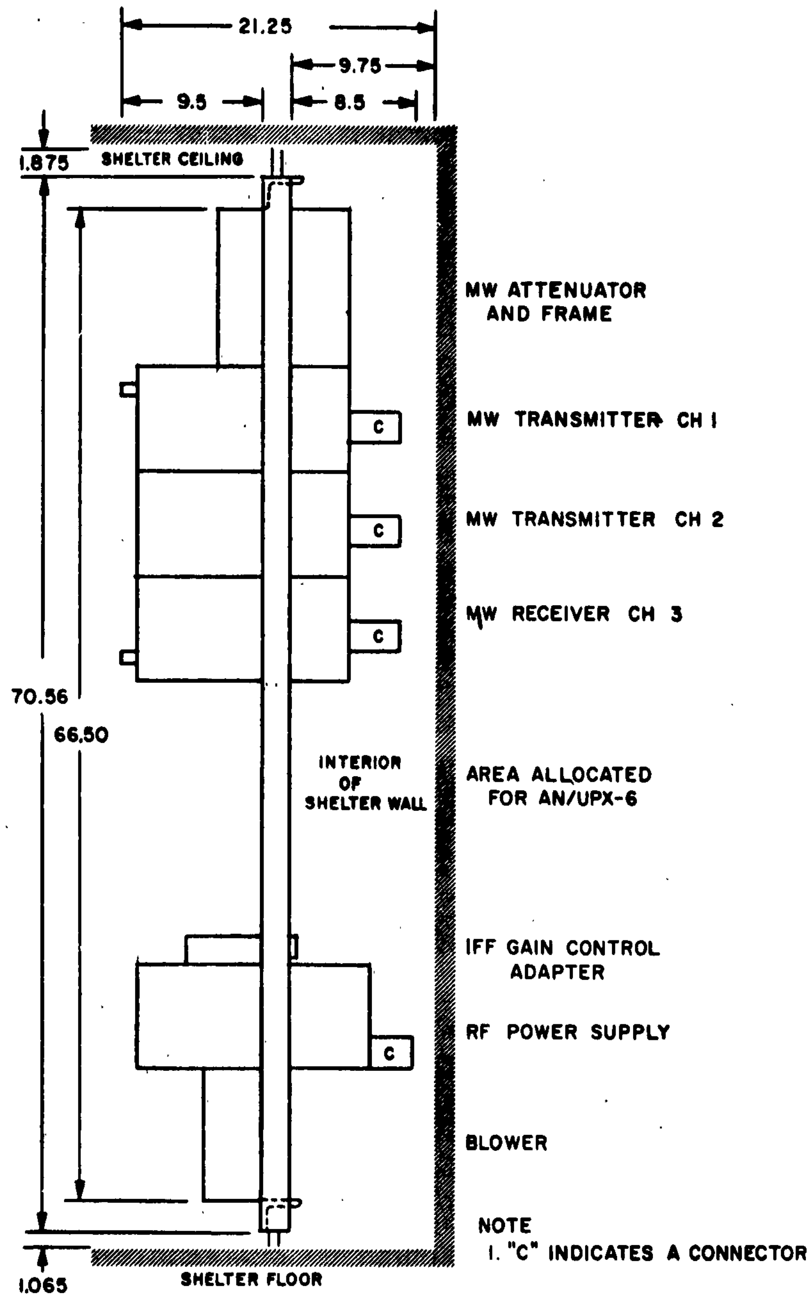


Figure 3-6. Search Microwave Terminal, Profile Rack No. 1

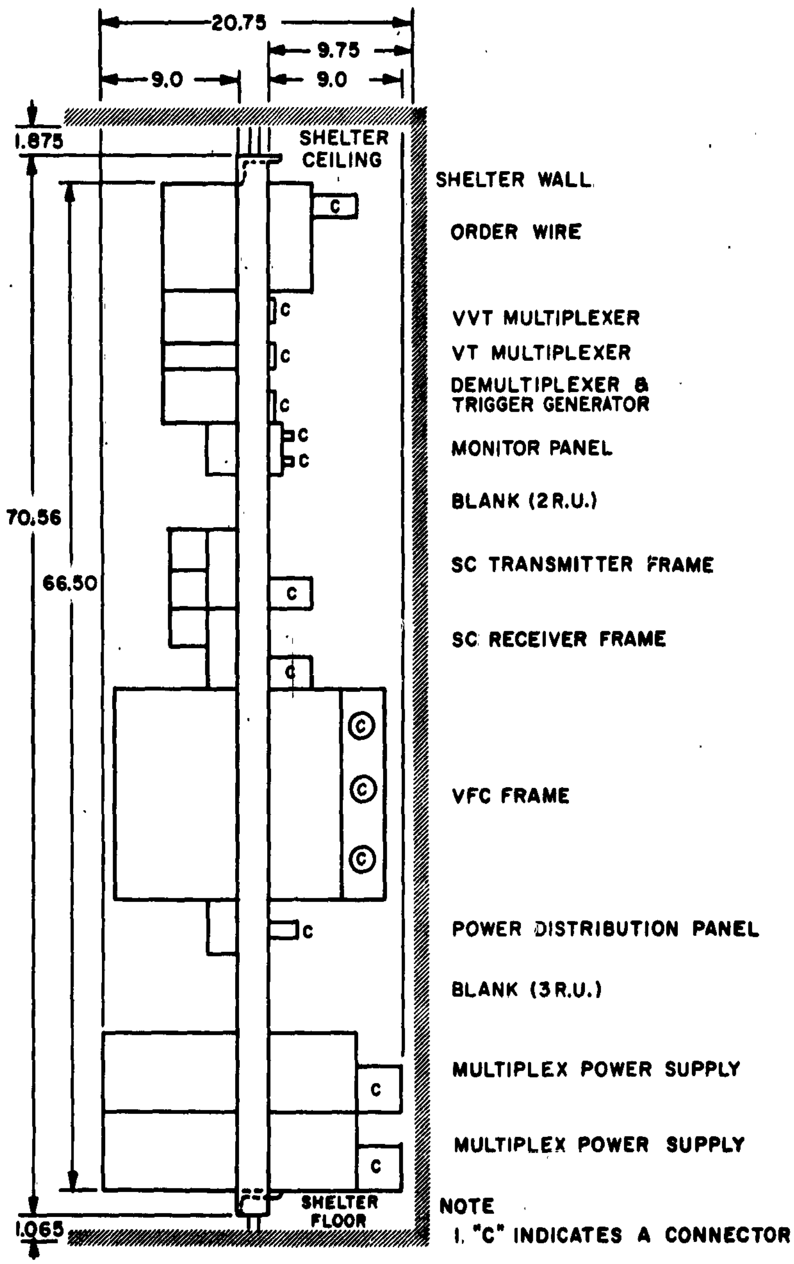


Figure 3-7. Search Microwave Terminal, Profile Rack No. 2

At the top of rack 1, the microwave attenuator is mounted in a frame which is in turn mounted on the rack. One end of the attenuator is attached to the common waveguide from the microwave receiver and transmitters. The opposite end of the attenuator is attached to the waveguide going to the microwave antenna. A cross guide coupler is inserted in the waveguide at a point which is most convenient for making tests. The waveguide from the attenuator passes through a hole at the pivot point of the rack, allowing the rack to rotate about the waveguide. A rotary joint or a flexible section must be used in the waveguide to allow the rack to rotate. A section of flexible waveguide is preferable if space is available.

The two microwave transmitters and the receiver are mounted beneath the attenuator. These units are coupled to the common waveguide, each section of which forms an integral part of the receiver or transmitter.

Beneath the microwave receiver and transmitters is space for the IFF receiver/transmitter. The IFF gain control adapter which adapts the IFF receiver for remote gain control via microwave is mounted directly beneath the IFF receiver/transmitter. The RF power supply which supplies regulated dc to the microwave receiver and transmitters is mounted beneath the gain control adapter.

At the bottom of the rack is the blower. This unit provides air to the microwave receiver and transmitters via an air duct which is attached to the left side of the rack. The blower is mounted at the bottom of the rack in order to pick up cooler air near the floor. This location is desirable but not essential, since a great deal of cooling is not required.

At the top of rack 2 is the order wire unit which is used for voice

communications to the opposite microwave terminal. Underneath the order wire is the VVT and VT multiplexers respectively. These units multiplex video and trigger signals for modulation of the microwave transmitters. Underneath the VT multiplexer is the demultiplexer and trigger generator which regenerates the beacon (IFF) trigger. Following the trigger generator is the monitor panel which is used to monitor or transfer the composite video signals to the transmitters and monitor the composite video signal from the receiver.

Below the monitor panel, a blank panel is inserted to cover a vacant space in the rack. Beneath this is the subcarrier transmitter frame which contains the three subcarrier (S. C.) transmitters for subcarrier channels 1, 2, and 3 which are used for transmitting antenna azimuth data. Directly beneath the subcarrier transmitter frame is the subcarrier receiver frame which contains the subcarrier receiver for subcarrier channel 4 used for receiving combined VFC control signals. Next is the VFC frame which contains the VFC (tone) receivers that provide control signals to the radar. Below the VFC frame is the power distribution panel which distributes and controls primary power to the units requiring it. A blank panel is located beneath the power distribution panel to fill vacant rack space.

At the bottom of the rack, two multiplex power supplies are located to provide ac and dc voltages for the multiplex equipment.

3.9.2 PAR MICROWAVE TERMINAL LAYOUT

The suggested rack layout of the PAR microwave terminal is shown in Figure 3-8. The equipment is contained in two racks. Profile views on racks 1 and 2 are shown in Figures 3-9 and 3-10 respectively.

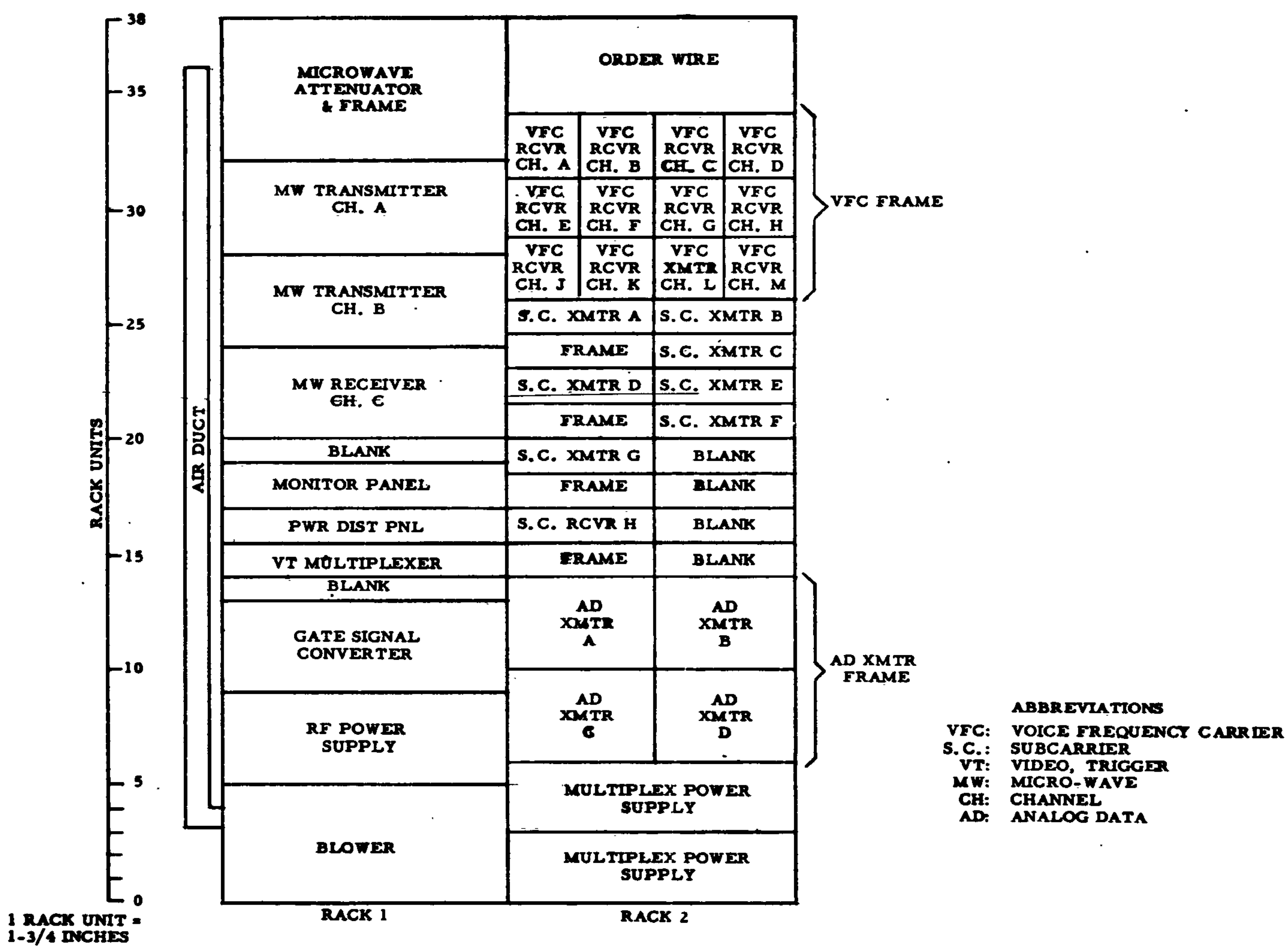


Figure 3-8. PAR Microwave Terminal, Equipment Layout

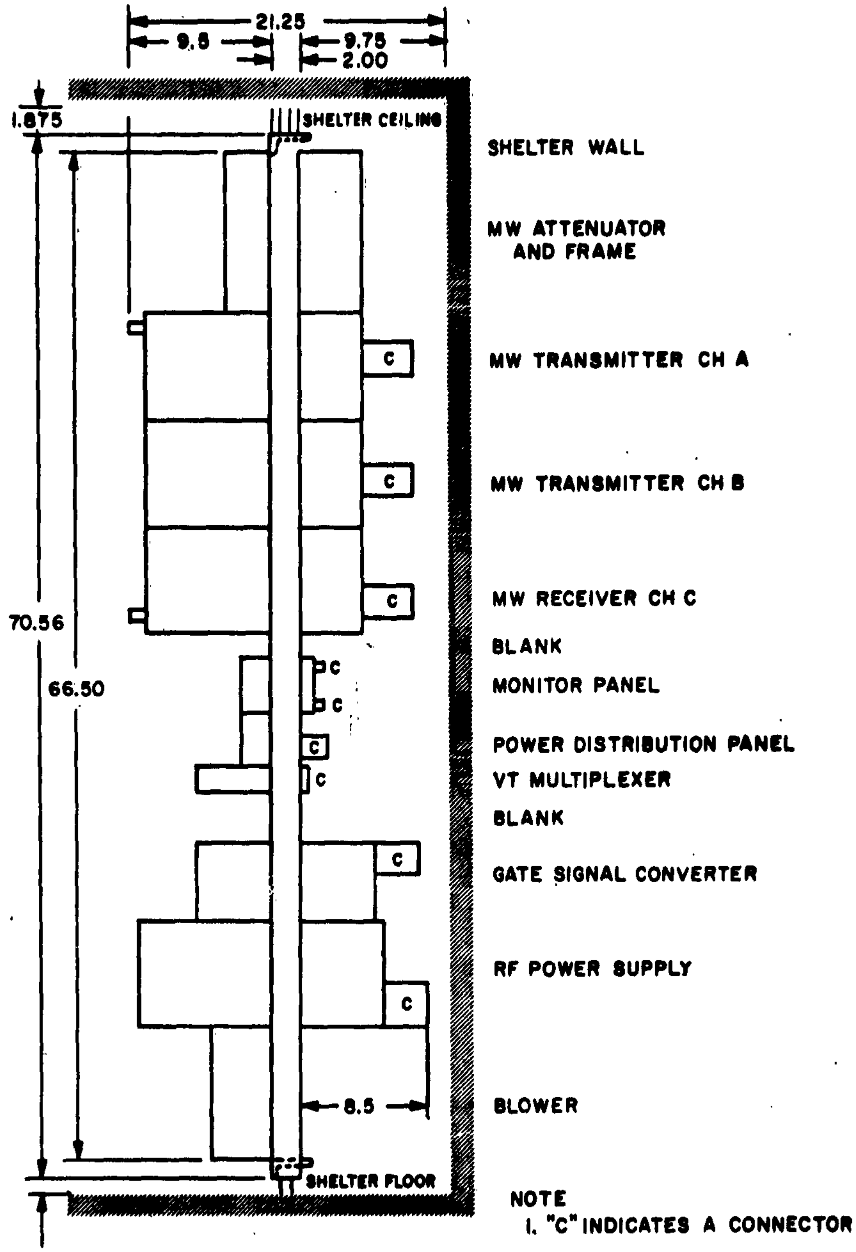


Figure 3-9. PAR Microwave Terminal Profile Rack No. 1

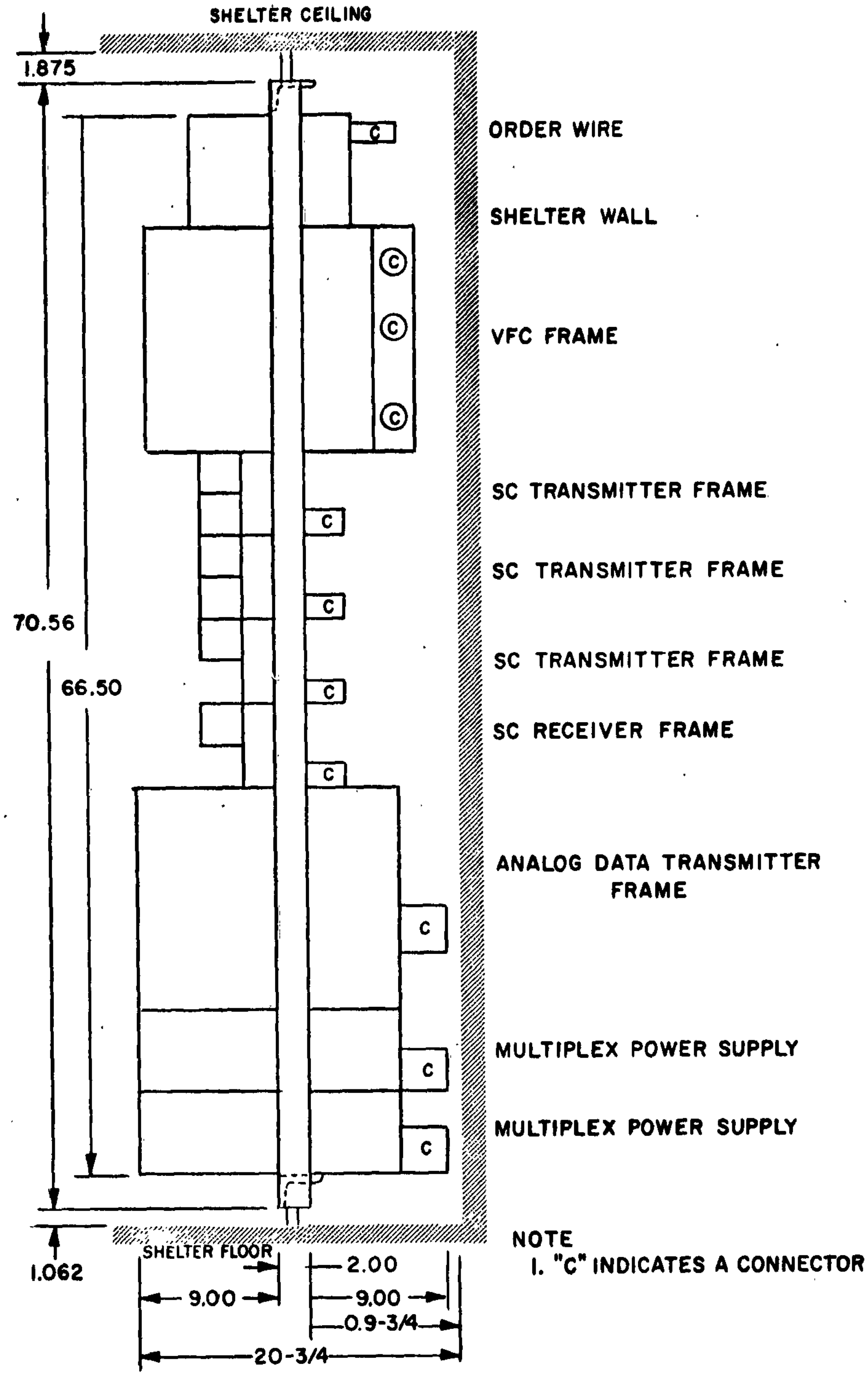


Figure 3-10. PAR Microwave Terminal, Profile Rack No. 2

At the top of rack one, the microwave attenuator and frame, two microwave transmitters, and a microwave receiver are mounted in the same manner as the same units in rack 1 at the search microwave terminal previously discussed. Next, from top to bottom, follow a blank panel, monitor panel, power distribution panel, VT multiplexer, and another blank panel, the function of which is the same as items previously discussed. The next item is the gate signal converter which converts two gate signals into forms suitable for transmission via microwave. At the bottom of the rack are the rf power supply and the blower, the functions of which are the same as in rack 1 of the search microwave terminal.

In rack two (from top to bottom) are contained the order wire for voice communications, the VFC frame with VFC receivers and transmitter for reception and transmission of control and indication signals, three subcarrier transmitter frames containing 7 subcarrier transmitters for various data, and one subcarrier receiver frame containing one subcarrier receiver for reception of combined VFC control signals.

Beneath the subcarrier receiver frame is the analog data (AD) transmitter frame containing four analog data transmitters which convert the position signals of the azimuth and elevation antennas into a form suitable for transmission via subcarrier transmitters.

At the bottom of rack 2 are two multiplex power supplies which provide ac and dc power to the multiplex equipment.

3.9.3 IFR MICROWAVE GROUP LAYOUT

The IFR microwave group consists of the IFR-search microwave terminal and the IFR-PAR microwave terminal. The suggested

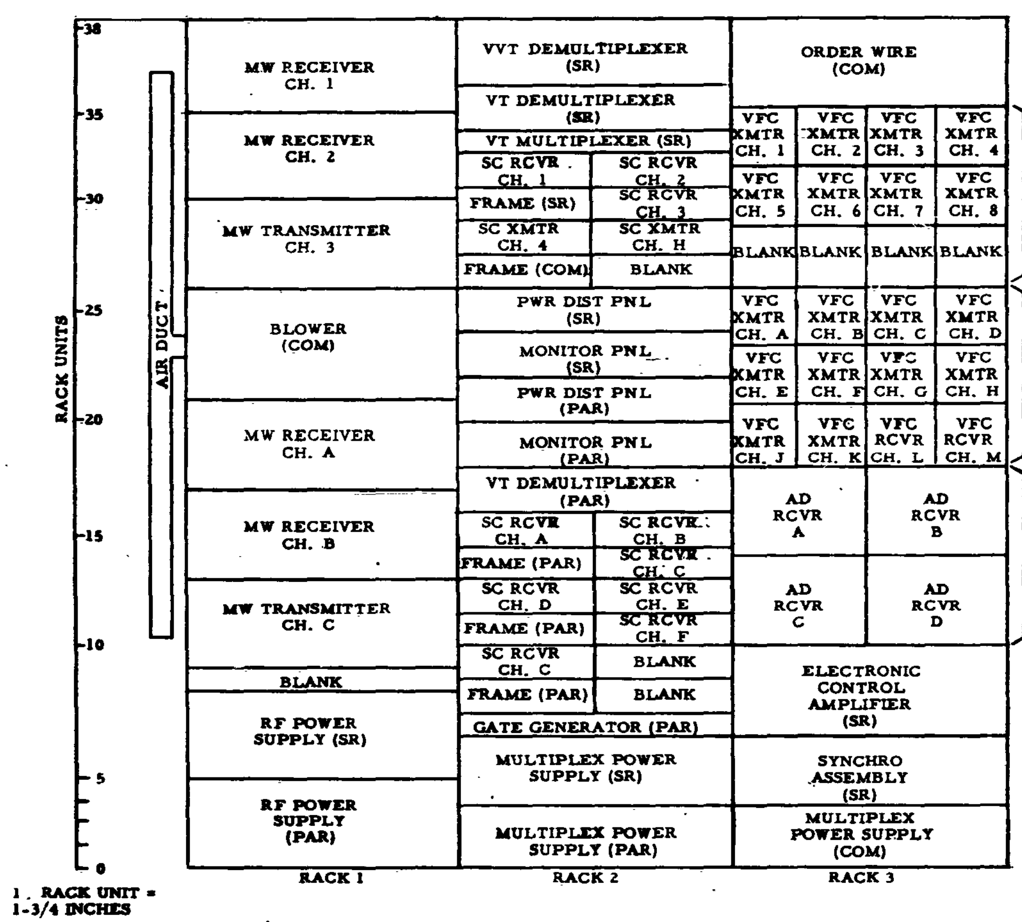
rack layout of the IFR microwave group is shown in Figure 3-11. The equipment is contained in 3 racks. Profile views of racks 1, 2, and 3 are shown in Figures 3-12, 3-13, and 3-14 respectively.

A. IFR-Search Microwave Terminal

In rack 1 are contained microwave channels 1 and 2 receivers, the channel 3 transmitter, and the power supply for these units. The receivers and transmitter are connected to a common waveguide which goes to the IFR-search microwave antenna. A cross guide coupler is inserted in the waveguide as a convenient test point. A common blower is shared by the receivers and transmitters of both the IFR-search and the IFR-PAR microwave terminal. In order to allow the rack to pivot, coaxial rotating joints are required, or flexible waveguides with quick disconnects, because two waveguides (one from each terminal) are brought out from the same rack.

In rack 2 are contained the VVT and VT demultiplexers which separate the composite video signals into separate video and trigger signals, a VT multiplexer via which the beacon (IFF) trigger is transmitted, subcarrier receiver frame containing channels 1, 2, and 3 subcarrier receivers for reception of antenna azimuth data, channel 4 subcarrier transmitter (in common subcarrier transmitter frame) for transmission of combined VFC control signals, a power distribution panel, a monitor panel, and a multiplex power supply.

Rack 3 contains the order wire (common to both terminals), channel 1 through 8 VFC transmitters in the SR (search radar) VFC frame, the electronic control amplifier, and the synchro assembly. These last two items are for conversion of the two speed resolver signals from the subcarrier receivers to one speed synchro signals for operation of the PPI indicators.



NOTE: NUMBERS DESIGNATE EQUIPMENT FOR IFR-SEARCH MW LINK, LETTERS DESIGNATE DQUIP. FOR IFR-PAR MW LINK.

ABBREVIATIONS

VFC: VOICE FREQUENCY CARRIER
SC: SUBCARRIER
VT: VIDEO, TRIGGER
VVT: VIDEO, VIDEO, TRIGGER
MW: MICROWAVE
CH: CHANNEL
AD: ANALOG DATA
PAR: PRECISION APPROACH RADAR MW LINK EQUIP.
SR: SEARCH RADAR MW LINK EQUIP.
COM: COMMON MW EQUIP.

Figure 3-11. IFR Microwave Group, Equipment Layout

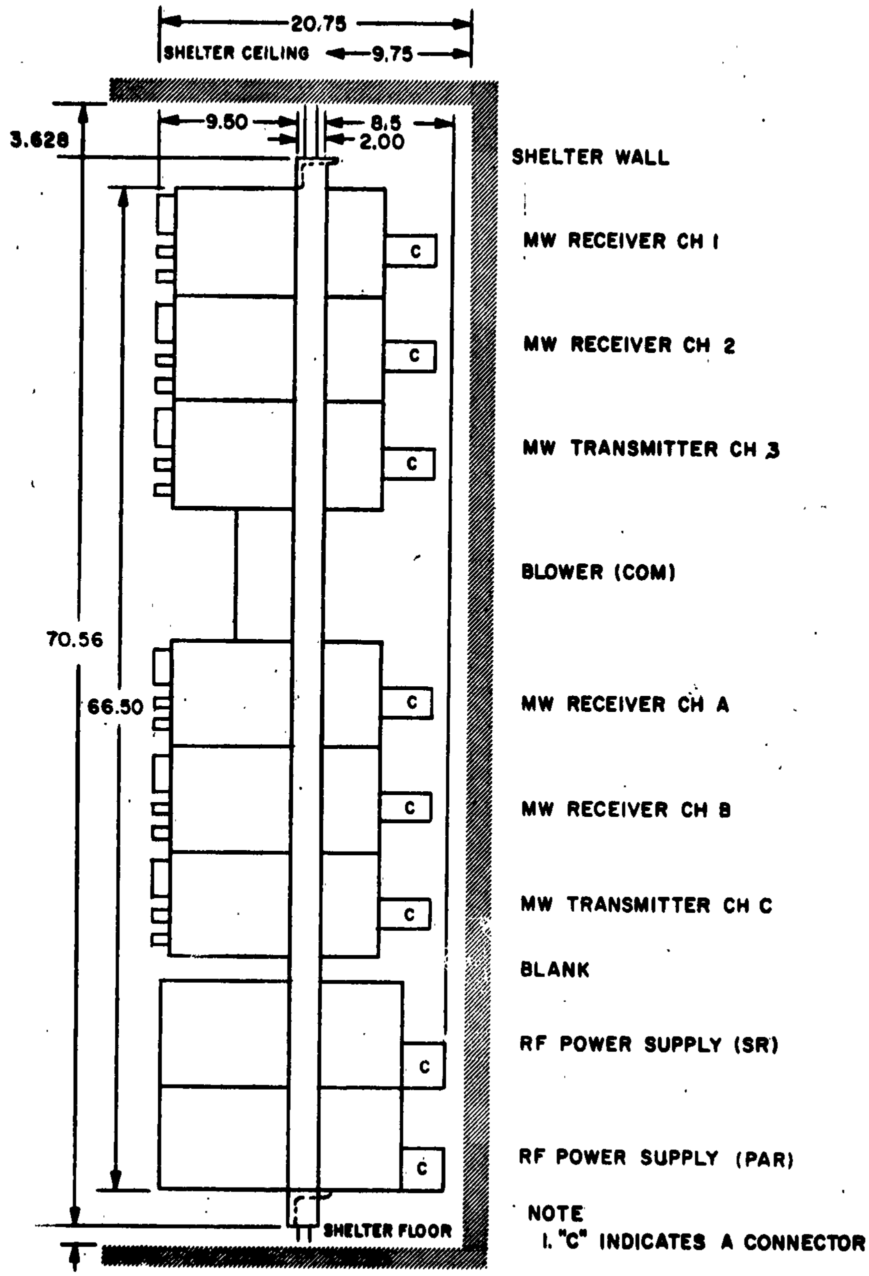


Figure 3-12. IFR Microwave Group, Profile Rack No. 1

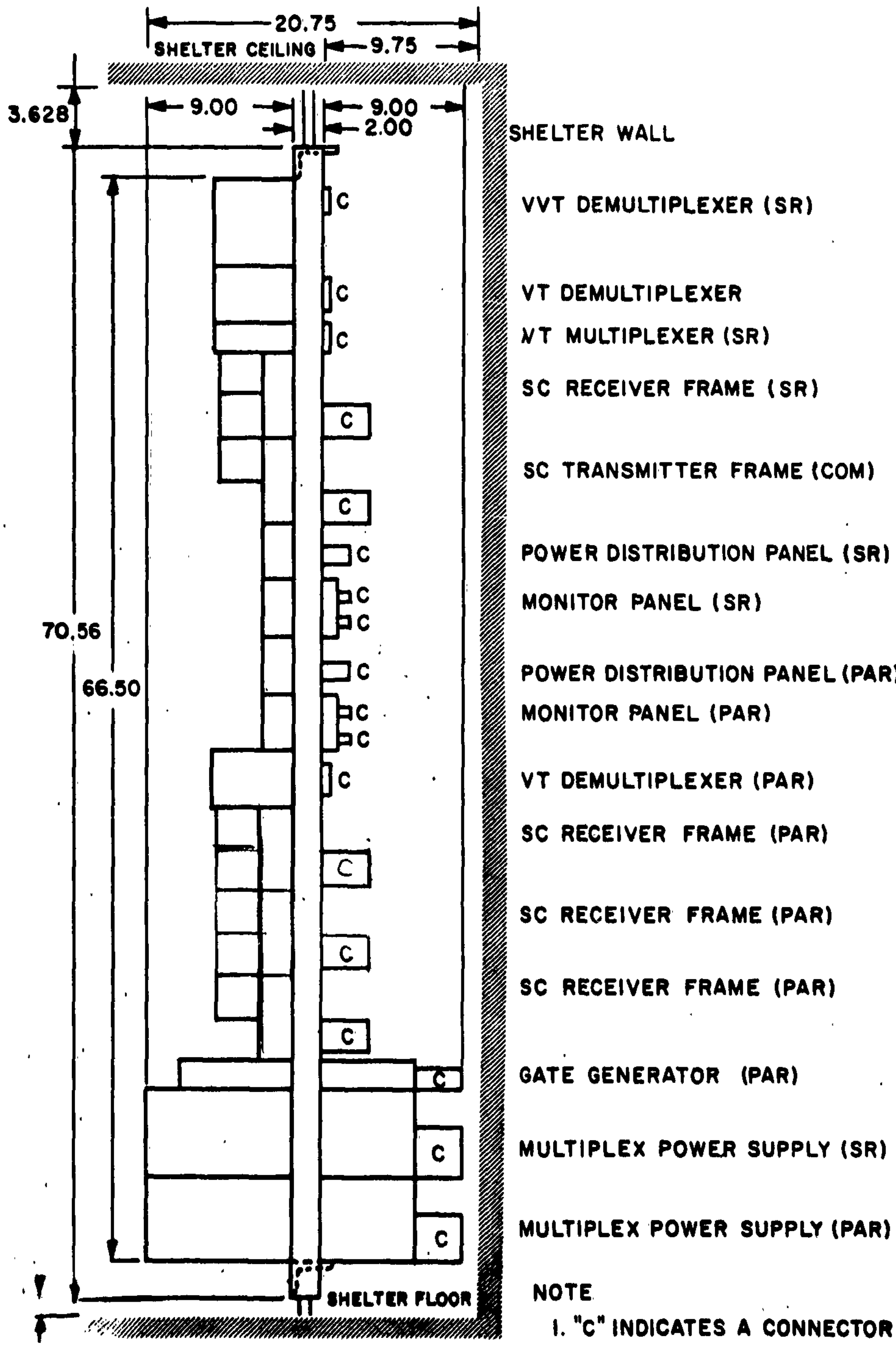


Figure 3-13. IRF Microwave Group, Profile Rack No. 2

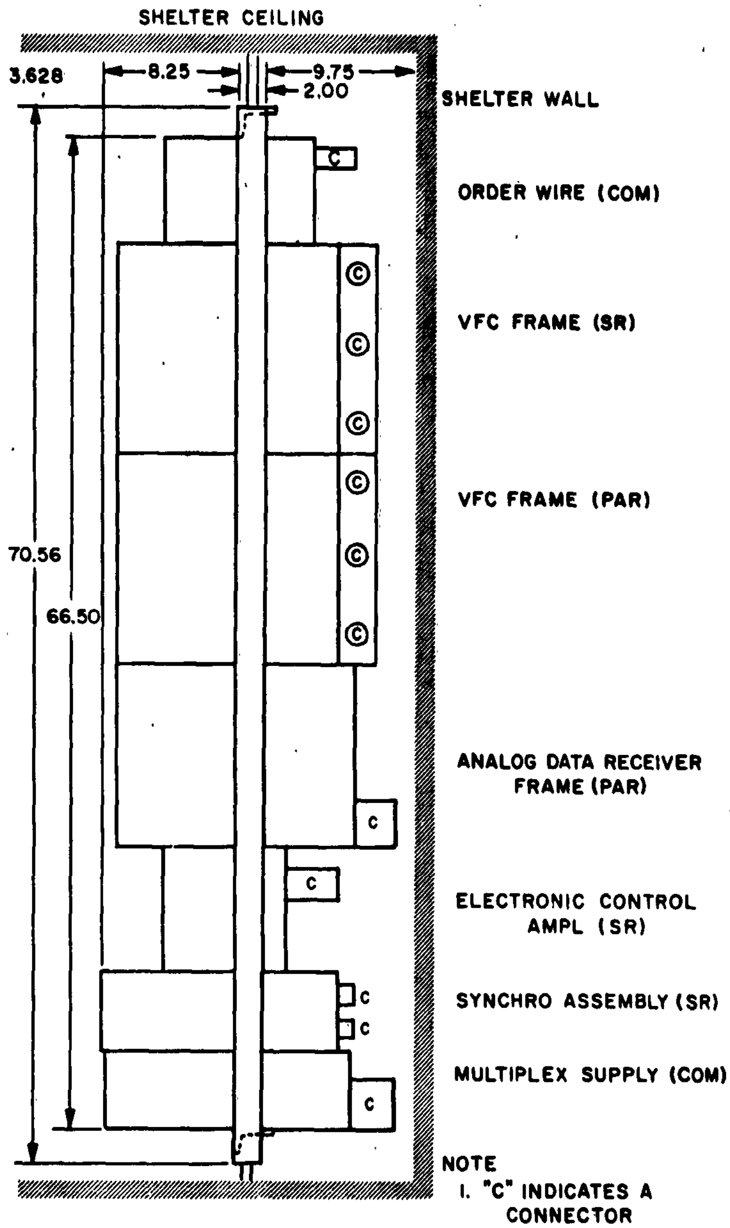


Figure 3-14. IFR Microwave Group, Profile Rack No. 3

B. IFR-PAR Microwave Terminal

This terminal shares the same three racks as the IFR-search terminal.

Microwave channels A and B receivers and Channel C transmitter are contained in rack 1 along with the rf power supply. The transmitters and receiver are connected to a common waveguide which goes to the IFR-PAR microwave antenna. A cross guide coupler is inserted in the waveguide as a convenient test point. Cooling is provided by a blower common to both terminals.

Rack 2 contains (from top to bottom) the following items of the IFR-PAR terminal: Channel H subcarrier transmitter in the common subcarrier transmitter frame, the power distribution panel, monitor panel, VT demultiplexer, three subcarrier receiver frames containing subcarrier receivers channels A through G, the gate generator which regenerates the relay gate and the unblanking gate, and the multiplex power supply.

Rack 3 contains the order wire (shared by both terminals), VFC transmitters channels A through K (I excluded) and VFC receivers channels L and M in the PAR VFC frame, analog data receivers A through D for reception of azimuth and elevation antenna position data, and a common multiplex power supply shared by both terminals.

3.10 CONSIDERATIONS FOR ESTABLISHMENT OF MICROWAVE LINKS

The establishment of reliable microwave links requires consideration of various aspects of the propagation of microwave energy as well as the range and deployment constraints among the components of the AN/TSQ-47. The latter constraints are discussed in the section on siting. The aspects of microwave transmission to be considered are

(1) Near field - far field
(2) Curved earth line of sight
(3) Atmospheric refraction
(4) Fresnel zone clearance

(5) Reflection lobes

(6) Side lobes

3.10.1 NEAR FIELD - FAR FIELD

Far field antenna radiation characteristics predominate at ranges greater than the ratio of the square of the antenna diameter to the operating wavelength, i.e., $R > D^2/\lambda$ where R = Critical Range. For the two microwave links of the AN/TSQ-47

(1) for D = 2 ft, λ =0.128 ft, R = 31 ft

(2) for D = 4 ft, λ =0.128 ft, R = 125 ft.

Since coaxial cable will be used for ranges less than 1000 feet, all considerations of the antenna propagation characteristics will involve only the far field properties.

3.10.2 CURVED EARTH LINE OF SIGHT

In order that two antennas spaced $D_1 + D_2$ apart, and at elevations h_1 and h_2 respectively, be in line of sight over a smooth earth, it is necessary that

$$h_1 \geq \frac{2}{3} D_1^2 \quad \text{and} \quad h_2' \geq \frac{2}{3} D_2^2$$

where h_1', h_2' are in feet, and D_1, D_2 are miles. The various quantities are shown in Figure 3-15A. However, these antenna heights must be modified to include atmospheric refraction.

3.10.3 ATMOSPHERIC REFRACTION

Radio energy does not travel in a straight line as assumed in the previous paragraph; rather, a slight bending is effected due to atmospheric conditions. As the value of refractive index K, changes, the degree and direction of bending also change. The basic equations given above, with refraction factor included, are

$$h_1 \geq \frac{2}{3}\frac{D_1^{\,2}}{K} \quad \text{and} \quad h_2 \geq \frac{2}{3}\frac{D_2^{\,2}}{K}$$

where, as above, h_1 and h_2 are in feet, and D_1 and D_2 are in miles. Normally the value of K is taken as 1.33, which effectively increases the earth radius to 4/3 the true radius. The various quantities are illustrated in Figure 3-15B.

3.10.4 FRESNEL ZONE CLEARANCE

Free space propagation conditions for operation of the microwave link antennas are assured if the first Fresnel zone clears all obstacles, including the earth. The first Fresnel zone radius is determined at the highest obstruction between the two microwave antennas. This obstruction is found by plotting a profile of the path on a true earth radius chart. Referring to Figure 3-15, the radius (about the line-of-sight path) of the first Fresnel zone at the highest obstruction is

$$R = 72\sqrt{\frac{D_1 D_2}{FD}}$$

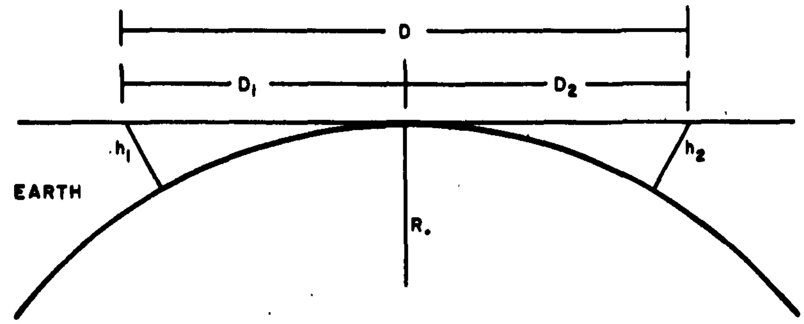
where R is in feet, D, D_1, and D_2 are in miles, and F, the frequency, is in kMc.

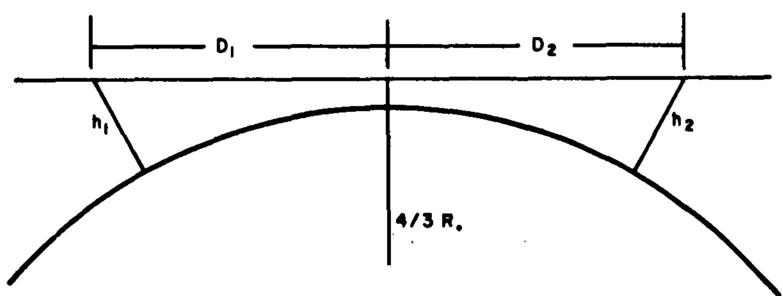
Figure 3-15C shows that the antenna elevation must be increased by R so that the first Fresnel zone does not intersect the earth at the highest obstruction. Hence, the minimum antenna heights become

$$H_1 = h_1 + R = h_1 + 72\sqrt{\frac{D_1 D_2}{FD}}$$

and

$$H_2 = h_2 + R = h_2 + 72\sqrt{\frac{D_1 D_2}{FD}}$$





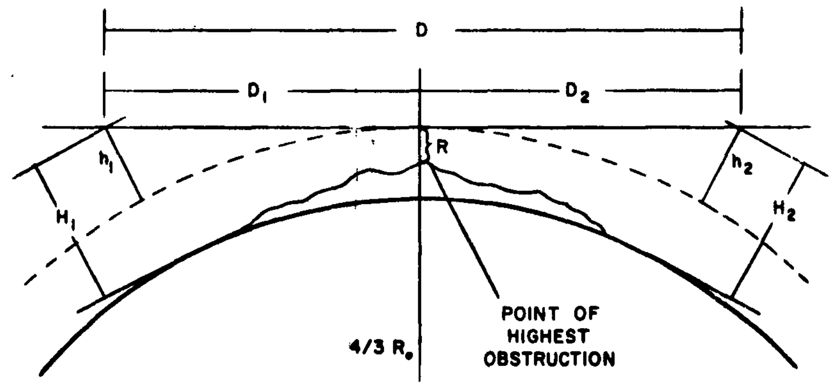


Figure 3-15. Line-of-sight path over curved earth including atmospheric refraction and first fresnal zone of radius R

In practice, the required Fresnel zone clearance is usually taken as 6/10 the Fresnel zone radius and the value of K as 1.33, as mentioned above; thus:

$$H_1 = \frac{D_1^2}{2} + 43.2\sqrt{\frac{D_1 D_2}{FD}}$$

$$H_2 = \frac{D_2^2}{2} + 43.2\sqrt{\frac{D_1 D_2}{FD}}$$

3.10.5 REFLECTION LOBES

The free space range of a microwave link is modified by reflections from the earth's surface according to the following factor, assuming a flat reflecting earth

$$F = 2 \sin \frac{2\pi h_1 h_2}{\lambda D}$$

where the units are consistent. For this factor to be a maximum

$$\frac{4 h_1 h_2}{\lambda D} = n$$

where "n" is an integer numbering the resultant lobes of the radiation pattern. For the microwave link, the "n" of interest will generally be unity. Therefore, for maximum usable range it is desirable to choose

$$4 h_1 h_2 = \lambda D.$$

It is to be remembered that the above condition applies to a flat reflecting surface only, and therefore only provides an estimate for field conditions. Reflections from irregular objects will materially affect the far field characteristics.

3.10.6 SIDE LOBES

Spurious signals transmitted or received in the antenna side lobes can cause degradation of the primary signal. However, all side-lobe signals are attenuated at least 18 or 22 db, so that the interference from side lobes should be relatively insignificant.

3.11 POSSIBLE IMPROVEMENTS IN MICROWAVE EQUIPMENTS AND SYSTEMS

In designing the microwave links previously discussed, the main objective was to accomplish the desired results by using "off the shelf" equipment and to employ a minimum of total equipment and of types of equipment. The following paragraphs list possible future improvements which could be accomplished by employing additional equipment or designing new or improved equipments.

3.11.1 TRANSMISSION OF PRECISION APPROACH RADAR DATA VIA ONE MICROWAVE CHANNEL

The IFR-PAR microwave link is presently designed to transmit the data from the PAR terminal to the IFR-PAR terminal via two microwave channels. If either of these channels fail, remote operation of the PAR is impossible until repairs can be made on the microwave equipment. If the essential data could be temporarily transmitted with slightly reduced performance via one microwave channel, the possibility of complete loss of remote PAR operation would be greatly reduced.

The present method of transmitting PAR data via microwave consists of transmitting the radar video and trigger via one full microwave channel and azimuth, elevation and gating data via subcarriers on another microwave channel. Figure 3-16 is a simplified block diagram of the IFR-PAR microwave link showing how the data is transmitted from the precision approach radar to the IFR center via microwave

channels A and B. The present spectrum utilization of the two microwave channels is shown in Figure 3-4.

A method of using only one microwave channel during an emergency in which the other failed is as follows: Transmit the two gate signals and the HV ON-OFF readback via tones on the microwave video baseband at frequencies below the radar prf. Transmit the radar video and trigger on the microwave video baseband as is presently done, but use a low pass filter to reduce the high frequency response of the video. Transmit the azimuth and elevation data for the two antennas via four subcarriers on the microwave video baseband at frequencies above the cutoff frequency of the low pass filter. Transmit the order wire signal at a frequency above the 7.0 Mc alarm signal. Suitable filtering will be required at the receiving end to separate some of the signals, and the order wire frequency would have to be changed for the IFR-search link as well IFR-PAR link because of the common order wire unit at the IFR center. Figure 3-16A is a simplified block diagram of the IFR-PAR microwave link showing the equipment configuration required for providing dual channel transmission of data from PAR to IFR center during normal operation and single channel transmission during emergency operation. Figure 3-17A shows the spectrum utilization of the two microwave video channels for normal operation and Figure 3-17B shows the spectrum utilization of the single video channel for emergency operation. When single channel operation is employed, the data is patched to the desired microwave channel by means of patch cables at the monitor panel at each end of the microwave link.

During this emergency operation, the gate signals would have greater delay, referenced to the input, and the rise time of the video would be increased, but performance would still be adequate. It can be seen that the design is such that transfer from normal to emergency operation

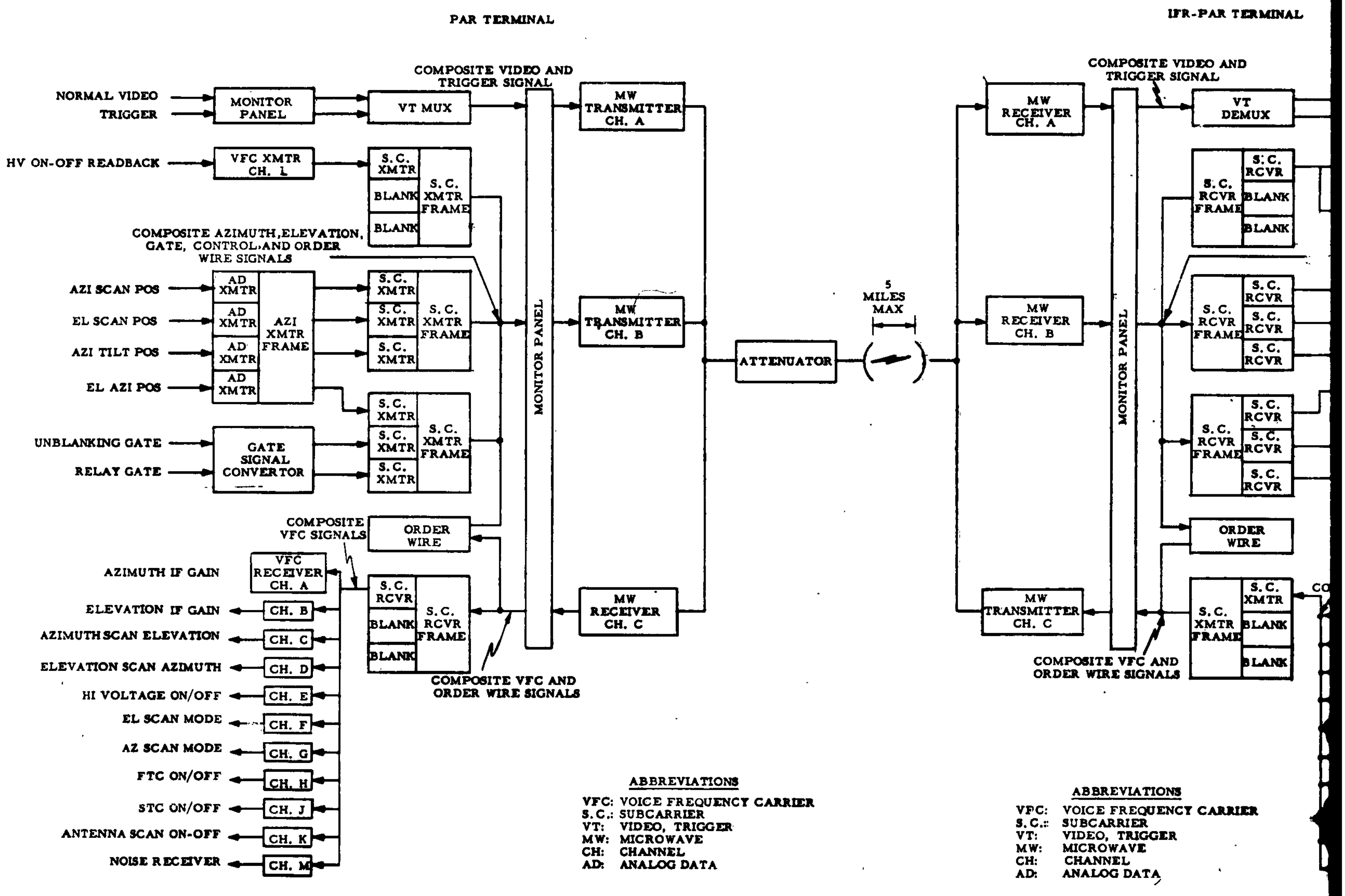


Figure 3-16. IFR-PAR Microwave Link, Simplified Block Diagram

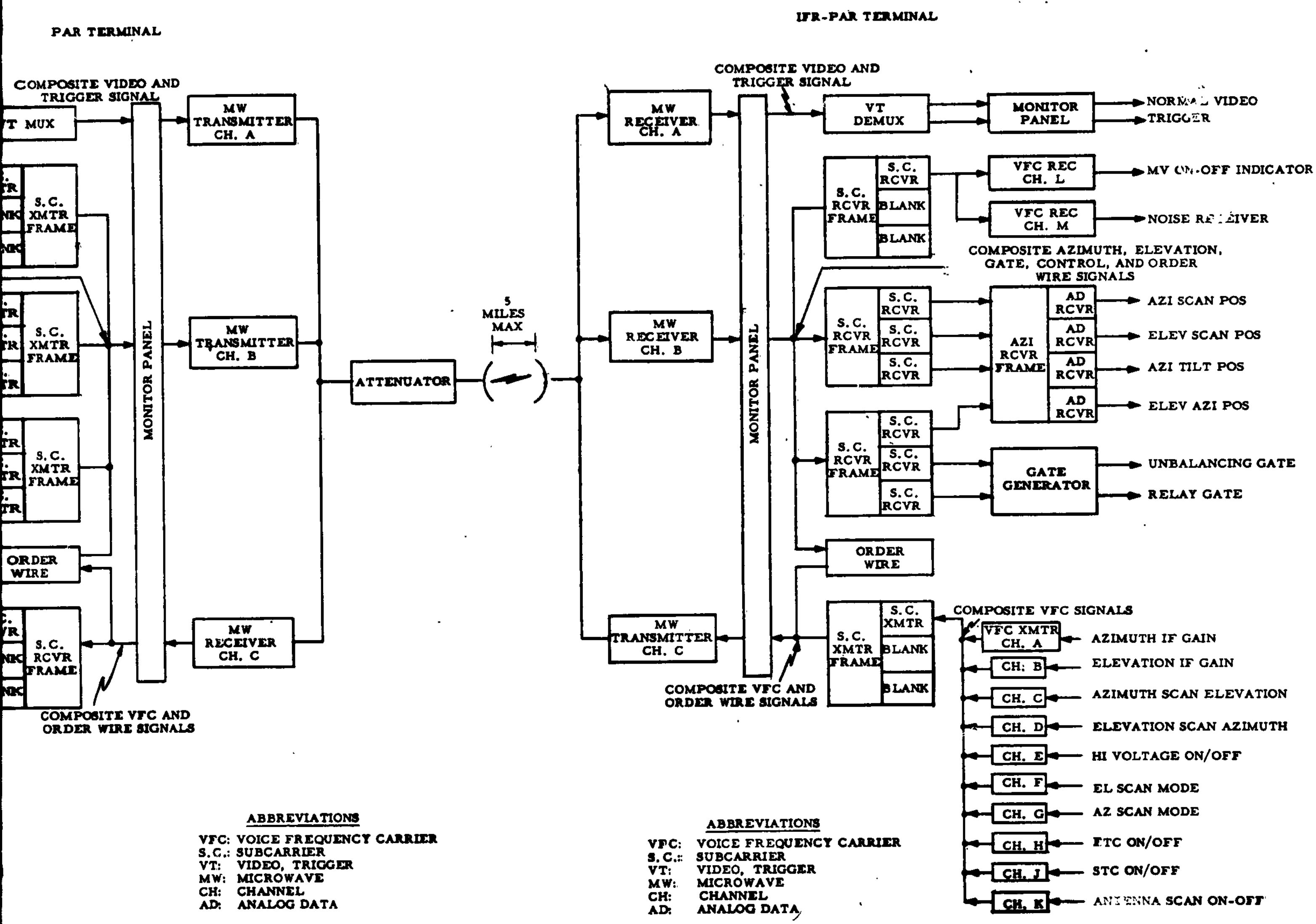


Figure 3-16. IFR-PAR Microwave Link, Simplified Block Diagram

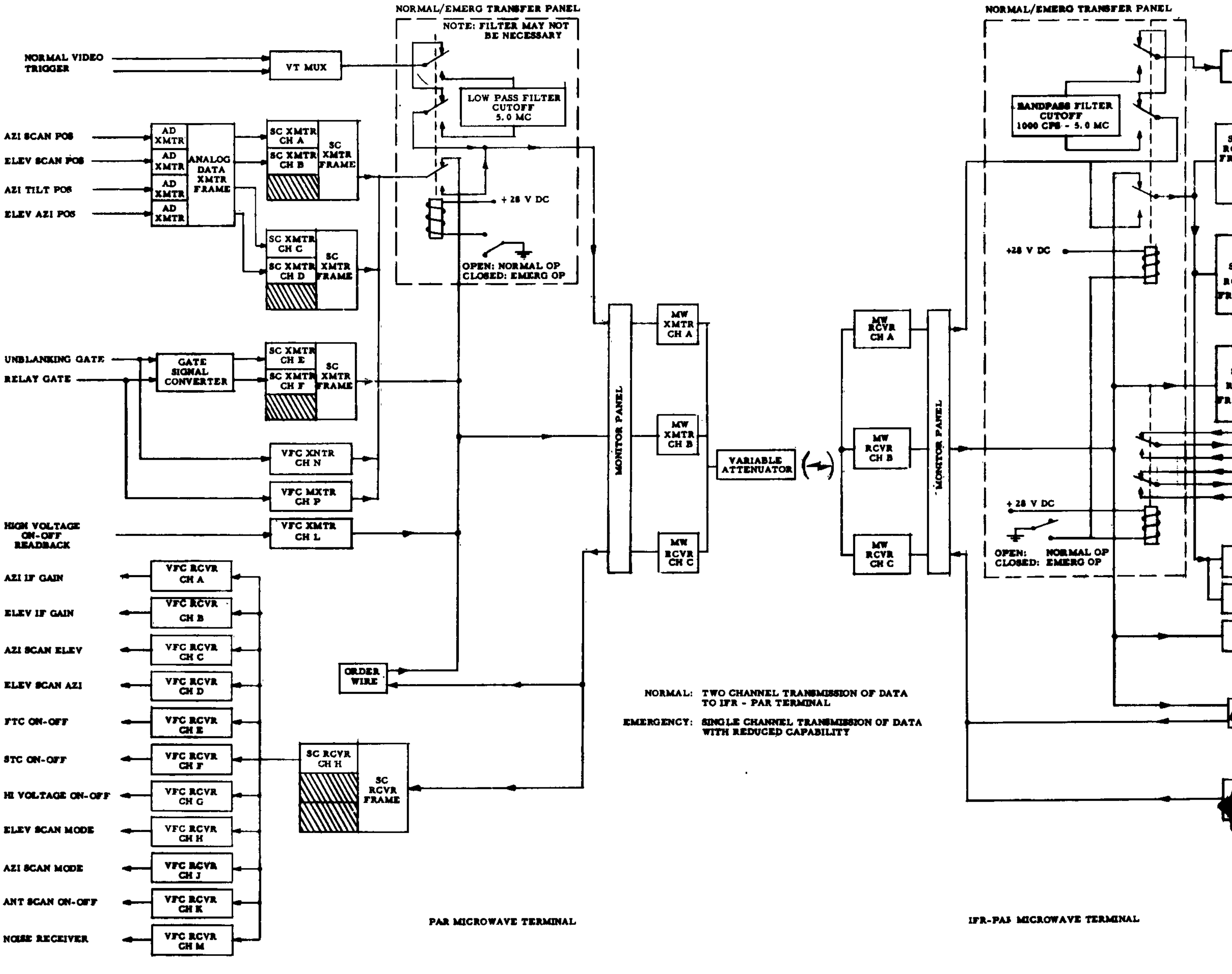


Figure 3-16A. IFR-PAR Microwave Link

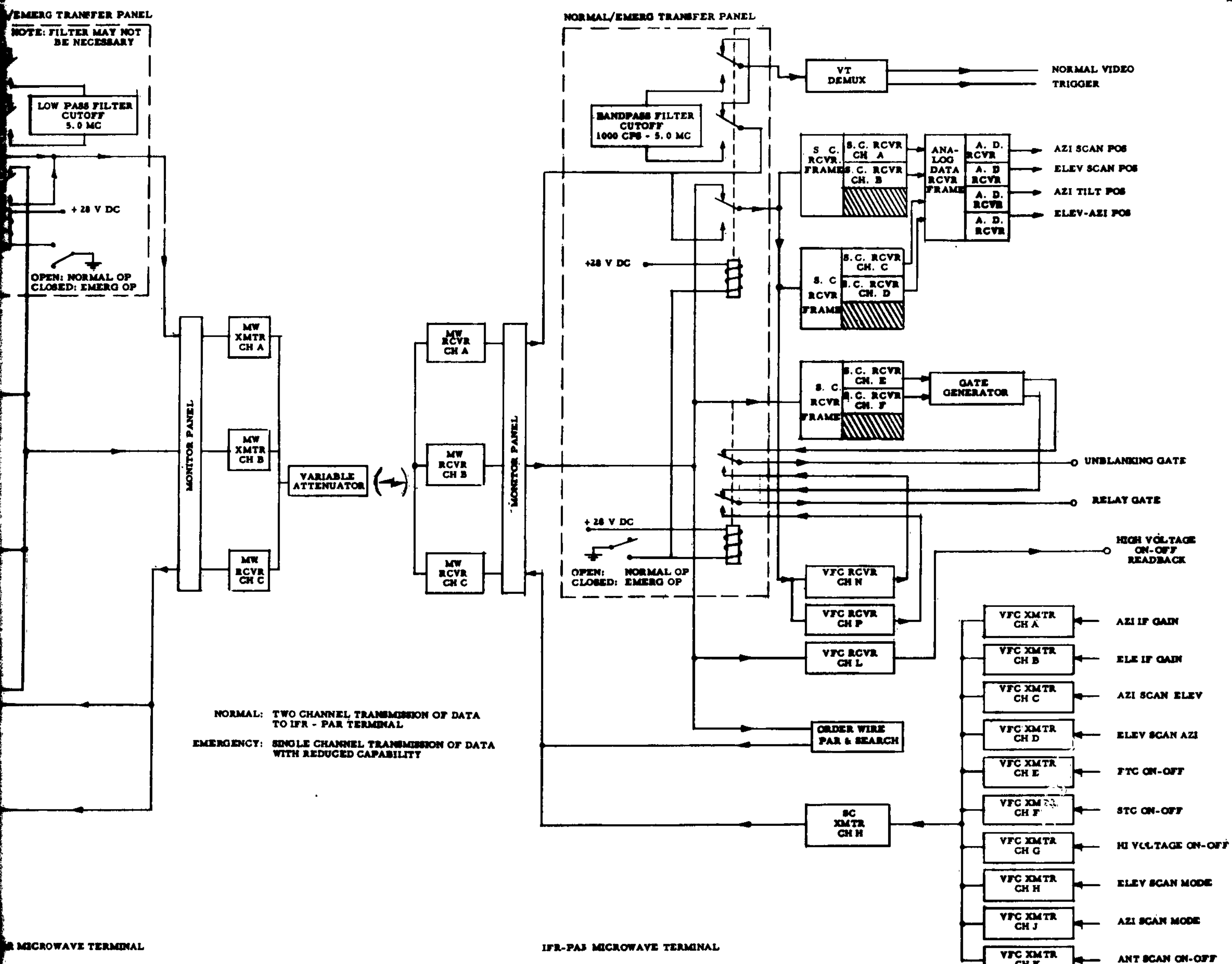


Figure 3-16A. IFR-PAR Microwave Link

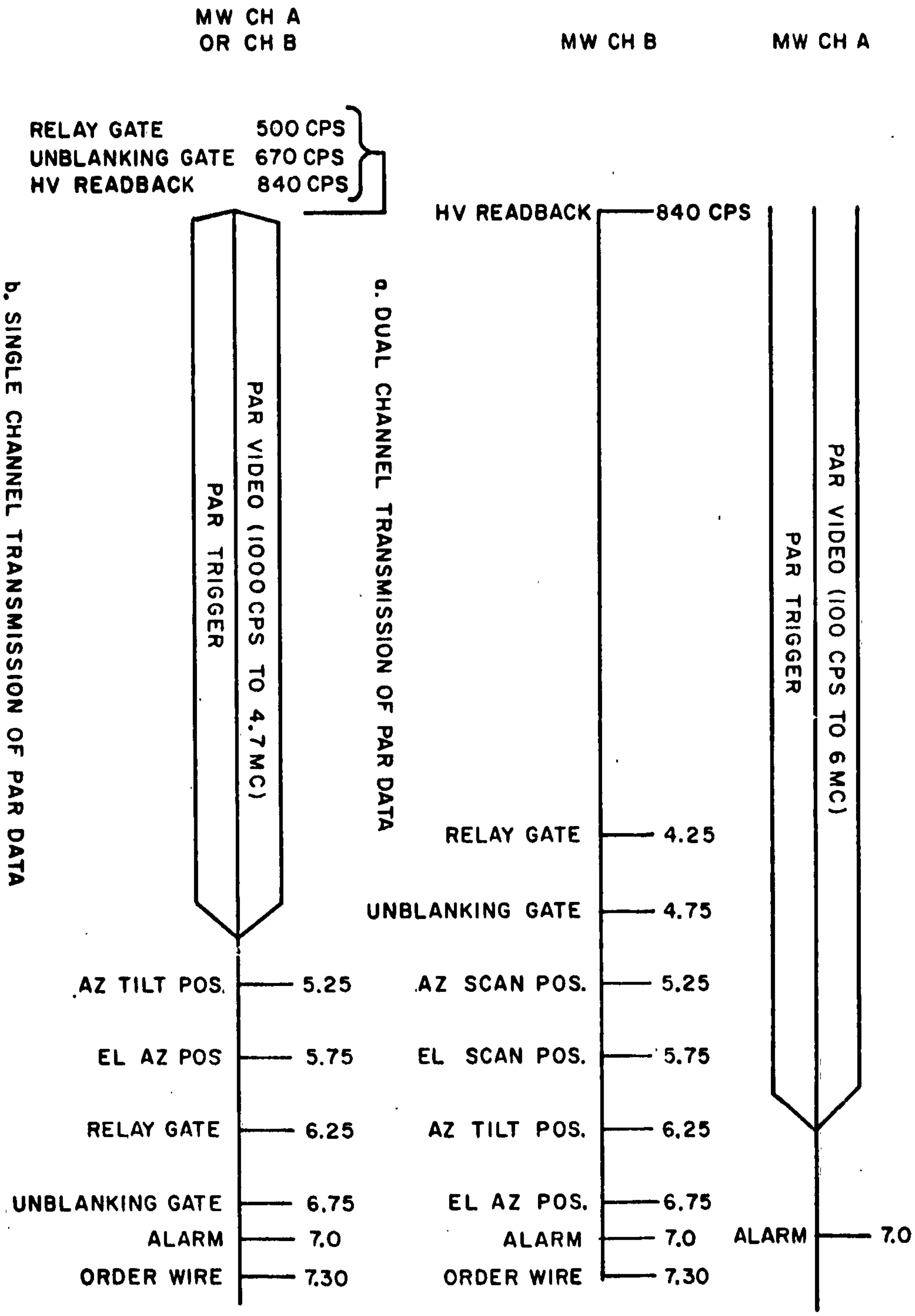

MW CH A OR CH B
RELAY GATE 500 CPS
UNBLANKING GATE 670 CPS
HV READBACK 840 CPS
PAR VIDEO (1000 CPS TO 4.7 MC)
PAR TRIGGER
b. SINGLE CHANNEL TRANSMISSION OF PAR DATA
AZ TILT POS. 5.25
EL AZ POS 5.75
RELAY GATE 6.25
UNBLANKING GATE 6.75
ALARM 7.0
ORDER WIRE 7.30
a. DUAL CHANNEL TRANSMISSION OF PAR DATA
MW CH B
HV READBACK 840 CPS
RELAY GATE 4.25
UNBLANKING GATE 4.75
AZ SCAN POS. 5.25
EL SCAN POS. 5.75
AZ TILT POS. 6.25
EL AZ POS. 6.75
ALARM 7.0
ORDER WIRE 7.30
MW CH A
PAR VIDEO (100 CPS TO 6 MC)
PAR TRIGGER
ALARM 7.0

Figure 3-17.

could be accomplished in a few seconds by personnel with little or no technical skill.

3.11.2 TRAVELING WAVE AMPLIFIERS FOR MICROWAVE TRANSMITTERS

The possibility of utilizing traveling wave amplifiers to improve the output power of the microwave transmitters should be investigated. Traveling wave amplifier tubes are available in the desired frequency band (7750 to 8400 Mc) with power output of 10 watts cw. This would provide a power gain of at least 20 db over the present microwave transmitters which employ klystrons; and, in addition to improving the fade margin, should greatly increase resistance to jamming.

Transmitters could be designed to include traveling wave tubes, or separate traveling wave amplifiers could be designed to operate in conjunction with the present transmitters.

3.11.3 ELIMINATION OF MOVING PARTS IN PPI INDICATOR

The possibility of utilizing the synchro assembly in the microwave to eliminate the synchro assemblies in the individual PPI indicators of the search radar should be investigated. Since this would eliminate one servo system in the chain from the radar antenna to the indicators, the accuracy of the azimuth data should be improved if everything else remains equal.

Figures 3-18A and 3-18B shows how the azimuth data is presently transmitted from the search radar to the indicators at the IFR shelter. The information is obtained in the form of sine waves displaced from a reference sine wave at the radar antenna. The sine waves are used to modulate subcarrier transmitters which in turn modulate a microwave transmitter. The composite signal is received via a microwave receiver at the opposite terminal and applied to the subcarrier

1

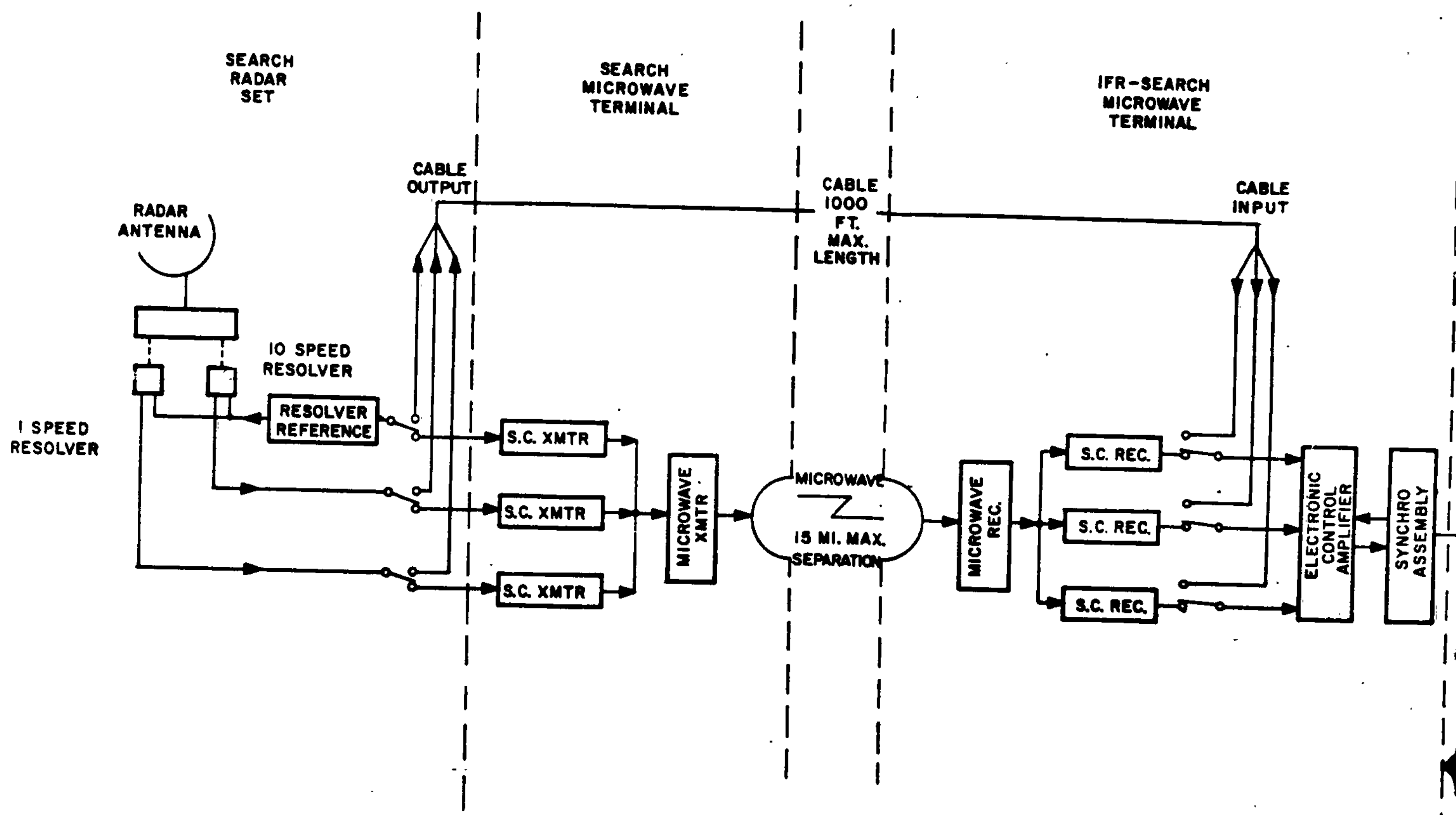


Figure 3-18. Present Method of Providing Azimuth Data via Microw

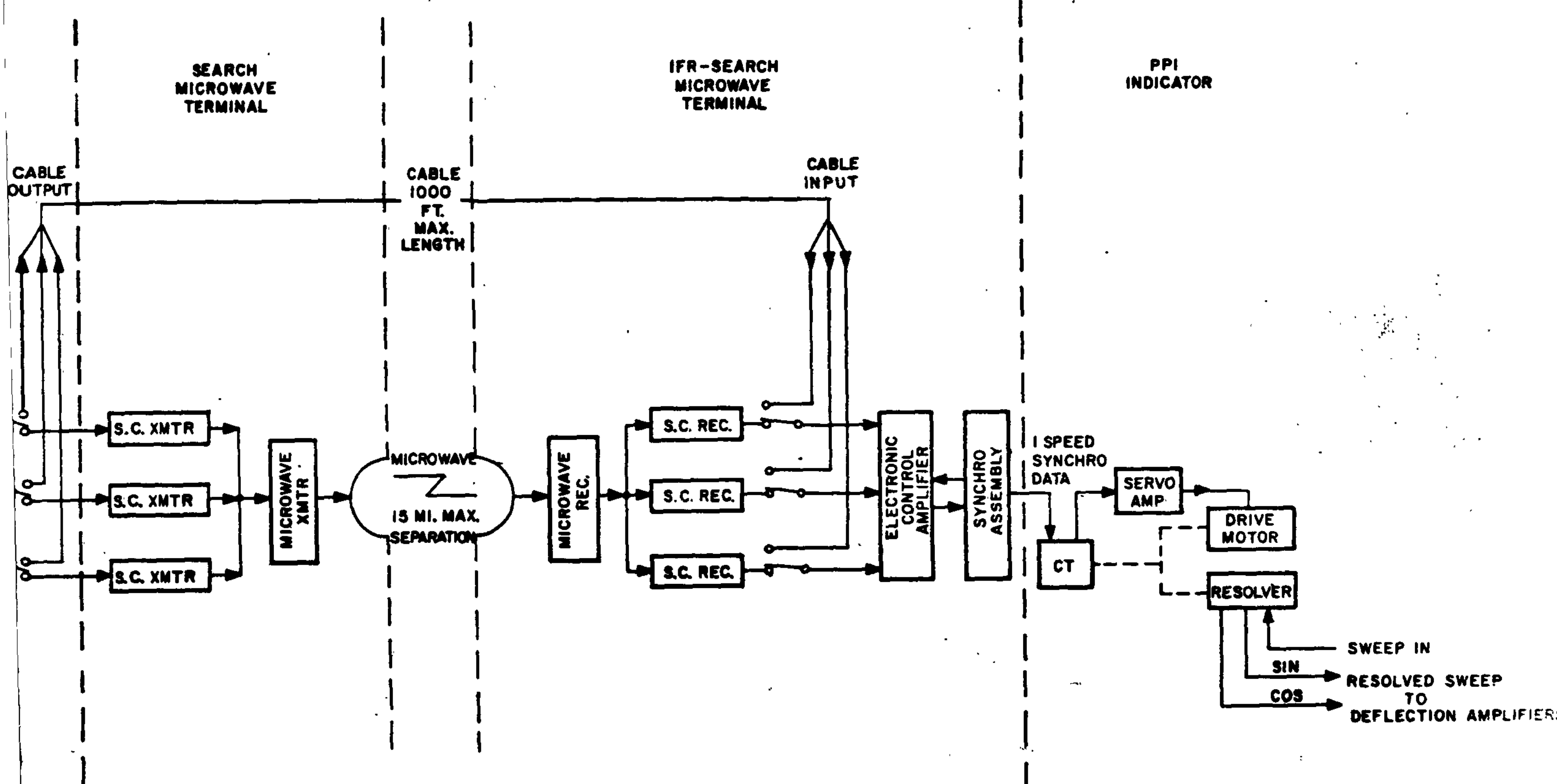


Figure 3-18. Present Method of Providing Azimuth Data via Microwave

receivers, the output of which is the original sine waves. These sine waves are applied to the electronic control amplifier which generates an error signal proportional to the error between the position of the radar antenna and the position of resolvers in the synchro assembly. The error signal is amplified and used to control a motor which drives the resolvers in the synchro assembly in a direction to reduce the error to zero. A synchro transmitter is geared to the motor and resolvers in the synchro assembly, and the output of this synchro transmitter is applied to a servo system in the indicator which positions a resolver according to the position of the radar antenna. The sweep voltage is applied to the resolver which converts it into sine and cosine components according to the position of the resolver. The resolved sweep is applied to the X and Y deflection coils of the indicator.

Figure 3-19 shows the proposed method of eliminating the servo system in the indicators. This should improve the reliability of the indicators since the indicators would now have no moving parts except small items such as switches, etc. Since a servo system has been eliminated, the accuracy should be improved as a result of eliminating the tracking error, synchro errors, inertia, and mechanical errors.

The proposed modification of the microwave equipment would consist of replacing the synchro transmitter in the synchro assembly with a resolver and addition of cathode followers. The resolver would be used to generate the resolved sweep which would go to the indicators via the cathode followers. One problem which may cause trouble is the capacity between the shields and the center conductors in cables which would carry the resolved sweep to the indicators. This could cause the sweep to be nonlinear. Fortunately, all cables at the IFR shelter could probably be kept to less than 20 feet. In addition, the shield could be driven by the cathode of the tube to which the sweep was applied at the indicator. Another solution may be to use compensating capacitors similar to those in an oscilloscope probe.

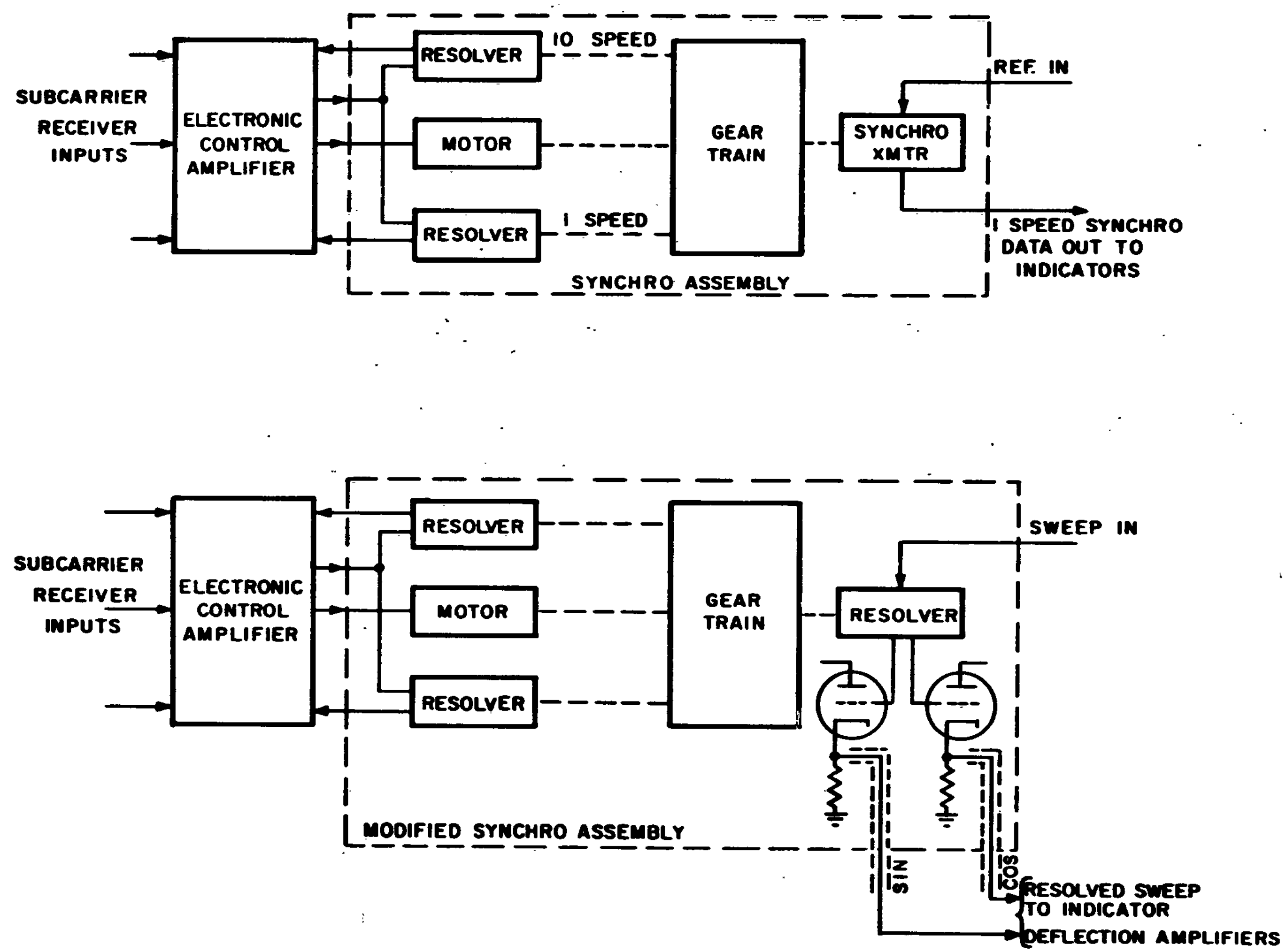


Figure 3-19. Details of Modified Synchro Assembly

If the servo system in the indicators could be eliminated, further improvements could be made in the microwave equipment by eliminating the synchro assembly. This could be accomplished by digital transmission of the azimuth data which could be converted to provide a resolved sweep electronically with no mechanical moving parts.

SECTION 4

CABLE REMOTING SYSTEM

Both the search radar and the PAR were required to have the capability of being remoted via cable as well as via microwave link. The maximum distance to be remoted via cable is 1000 feet for each radar set. Both the microwave and the cable remoting system are required to be compatible in order to allow transfer from microwave to cable or vice-versa without the necessity of using different control units or adapters for each mode of operation.

4.1 SEARCH RADAR CABLE REMOTING REQUIREMENTS

The signals to be remoted to or from the search radar are the same as for microwave and are listed in Table 4-1. The performance via cable should equal that obtained via microwave. Since the microwave link can be adjusted to maintain the required output levels, the cable may require line drivers and/or equalizers to provide the required output levels. The same result could possibly be obtained by driving the cables with higher input levels than that specified for the microwave. The major problem will be encountered with the video signals and will depend upon the amount of loss in the coaxial cables. Recommended cabling required for remoting the search radar is given in Table 4-1.

Table 4-1. Cabling required for remoting the search radar

Type Cable or Conductor	Quantity	Associated Signals and Remarks
Low loss co-ax cable	6	1. Normal video 2. MTI (special) video 3. Radar trigger 4. IFF (Beacon) video 5. Radar pre-trigger 6. IFF mode pulses (beacon trigger)
Miniature co-ax or shielded single conductor	3	1. Antenna azimuth, coarse resolver signal 2. Antenna azimuth, fine resolver signal 3. Antenna azimuth, resolver reference Co-ax may be required in place of shielded single conductors in order to maintain uniform change of capacitance in each cable with changes in temperature.
Twisted pair	2 pair	1. Order wire communication (via wire) 2. Spare
Single conductor	17	1. Normal video IF gain control (CW) 2. Normal video IF gain control (CCW) 3. MTI video IF gain control (CW) 4. MTI video IF gain control (CCW) 5. IFF (Beacon) receiver gain control (CW) 6. IFF (Beacon) receiver gain control (CCW) 7. STC gain control (CW) 8. STC gain control (CCW) 9. FTC IN-OUT control 10. Circular Polarization IN-OUT control 11. PWD IN-OUT control 12. STC IN-OUT control 13. Ground return (may require larger diameter than other conductors) 14. Spare 15. Spare 16. Spare 17. Spare

All of the above should be included in one cable. This could be attained by encapsulating everything into one unit, or by using a special covering such as Zipper Tubing to hold several separate cables together.

4.1.1 ADDITIONAL MODIFICATION OF SEARCH RADAR FOR OPERATION VIA CABLE

No additional modification of the search radar from that required for operation via microwave will be required for operation via cable.

4.2 PRECISION APPROACH RADAR CABLE REMOTING REQUIREMENTS

The signals to be remoted to or from the PAR are the same as for microwave and are listed in Table 4-2. The performance via cable should equal to the performance obtained via microwave. Since the microwave link can be adjusted to maintain the required output levels, the cable may require line drivers and/or equalizers in order to provide the required output levels. The same result could possibly be obtained by driving the cables with higher input levels than that specified for the microwave. The major problem will be encountered with the video signals and will depend upon the amount of loss in the coaxial cables. Recommended cable for remoting precision approach radar is given in Table 4-2.

Table 4-2. Cable required for remoting the PAR

Type Cable or Conductor	Quantity	Associated Signals and Remarks
Low loss co-ax cable	2	1. Normal video 2. Radar trigger
Shielded single conductor	6	1. Az position of Az scan antenna 2. El (tilt) position of Az scan antenna 3. El position of El scan antenna 4. Az position of El scan antenna 5. Unblanking gate 6. Relay gate
Twisted pair	2 pair	1. Order wire communication (via wire) 2. Spare

Table 4-2 (Continued)

Type Cable or Conductor	Quantity	Associated Signals and Remarks
Single conductor	20	1. Elevation IF gain control (CW) 2. Elevation IF gain control (CW) 3. Elevation (tilt) control of Az scan antenna (UP) 4. Elevation (tilt) control of Az scan antenna (DOWN) 5. Azimuth IF gain control (CW) 6. Azimuth IF gain control (CW) 7. Azimuth control of El scan antenna (CW) 8. Azimuth control of El scan antenna (CCW) 9. HV ON-OFF control 10. HV ON-OFF control 11. El scan mode control 12. Az scan mode control 13. Antenna scan ON-OFF control 14. FTC IN-OUT control 15. STC IN-OUT control 16. HV ON-OFF indication 17. Spare 18. Spare 19. Spare 20. Spare

All of the above should be included in one cable. This could be attained by encapsulating everything into one unit, or by using a special covering such as Zipper Tubing to hold several separate cables together.

4.2.1 ADDITIONAL MODIFICATION OF PAR FOR OPERATION VIA CABLE

No additional modification of the PAR from that required for operation via microwave will be required for operation via cable.

SECTION 5

IFF/SIF CONFIGURATION

There are many different equipments available at the present time to satisfy the needs of the A4W SIF/IFF requirements. However, due to the weight and space limitation, the following four configurations are included to show size and weight comparisons:

5.1 GENERAL

The decoder group, when used in conjunction with a Mark X IFF interrogator response system, provides the system with Selective Identification Feature (SIF) capability. The decoder group provides decoding of three modes of interrogation:

Mode I	Security Identification (SI)
Mode II	Personnel Identification (PI)
Mode III	Traffic Identification (TI)

It will provide selectable outputs on a PPI display to allow immediate identification of a friendly aircraft and its relative position. It will supply independent control of codes and modes of operation for each position containing a control panel and decoder unit.

5.1.1 SYSTEM I

The following system (Figure 5-1) contains off-the-shelf equipment and will meet the requirements of a three-position system:

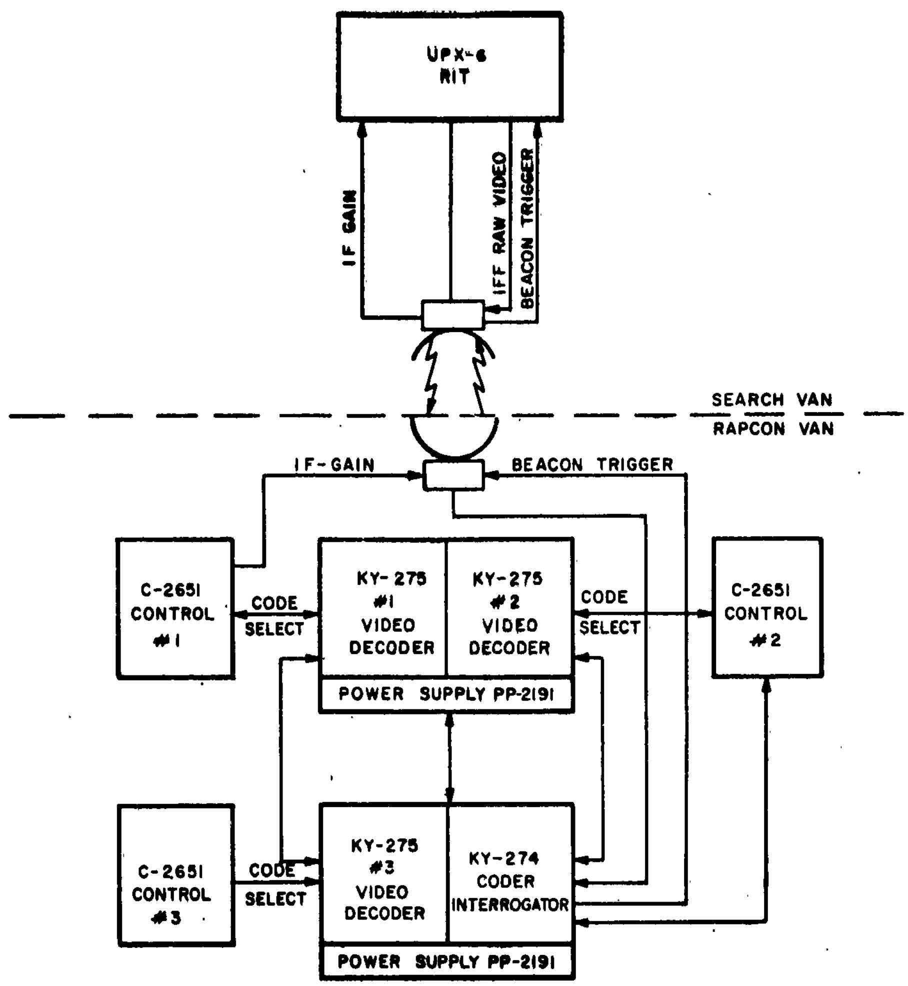


Figure 5-1. System No. 1

Nomenclature	Form Name	Total
Video Decoder KY-275/GPX	Video Decoder	3
Coder-Interrogator Set KY274/GPX	Coder Synchronizer	1
Coder-Decoder Control C-2651/GPX	Control Panel	3
Power Supply PP-2191/GPX	Power Supply	2
Interrogator Responder AN/UPX-6	Transmitter/Receiver	1

System Weight and Size

Rapcon Location	Inches W/H/L	Wt. in lbs	Search Radar Van	Inches W/H/L	Wt. in lbs
2 Video Decoder plus Power Supply	21-1/2 x 16-1/2 x 25	50	UPX-6	15x11x21	77
1 Video Decoder, 1 Coder, 1 Power Supply	21-1/2 x 16-1/2 x 25	48			
3 Control Supply	13-1/2 x 15-1/2 x 14-1/2	17			77
Total Weight		149			

Comments: The system supplies interlace of modes which is not a requirement; the system gives independent code selection and mode selection te each of three positions; the system is in the field at the present time and could be obtained without production.

5.1.2 SYSTEM II - The following system (Figure 5-2) contains the UPX-6 Interrogator Response Unit, in conjunction with the Coder Beacon KT-166 and Decoder Group KY-299

Nomenclature	Form Name	Total
Decoder Group KY-299 Contains:		
Decoder MX-2825	Decoder	3

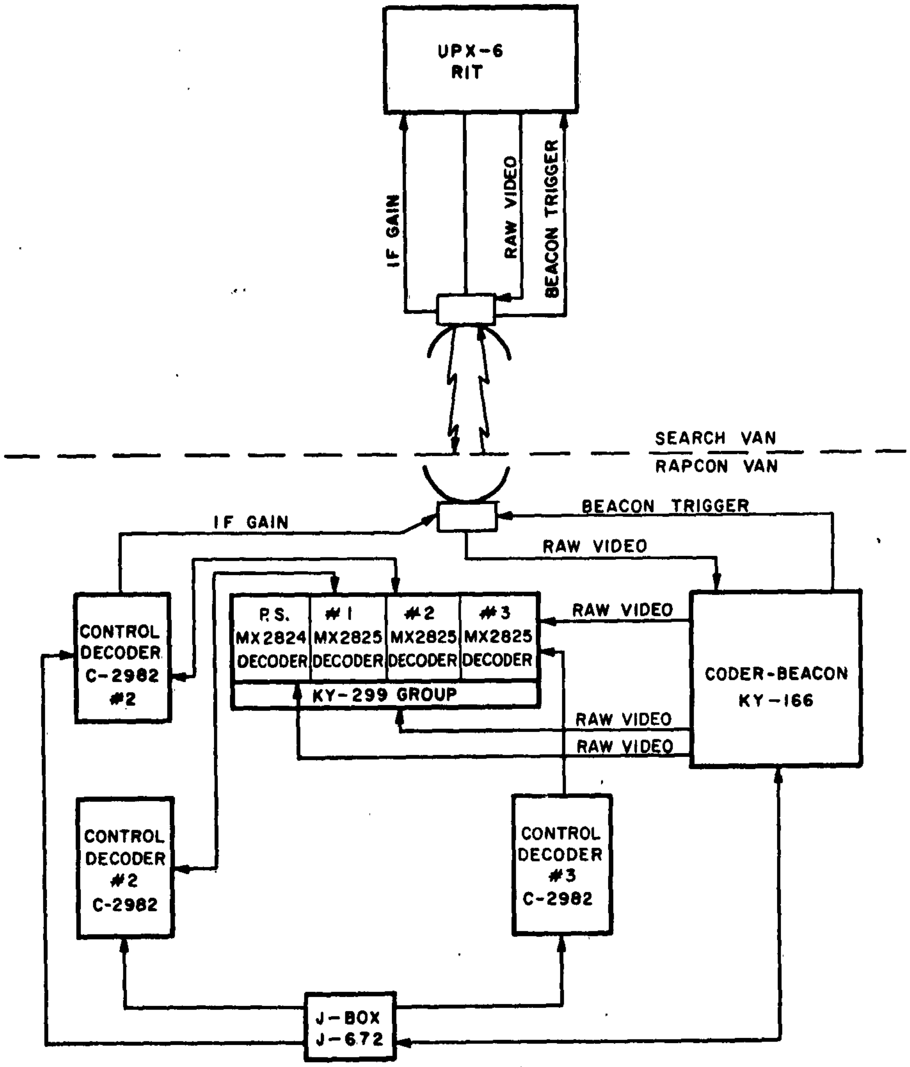


Figure 5-2. System No. 2

Nomenclature	Form Name	Total
Mounting Rack MT-1570	Electrical Equipment Rack	1
Inter-connecting Box J-672	Junction Box	1
Control Decoder C-2982	Control Panel	3
Interrogator Responder AN/UPX-6	Receiver/Transmitter	1
Decoder Pulse MX-2824	Decoder/Power Supply	1
Coder Beacon KY-166	Encoder	1

<u>System Weight and Size</u>

Rapcon Location	Inches W/H/L	Wt. in lbs	Search Radar Van	Inches W/H/L	Wt. in lbs
Decoder Group KY-299	19-1/2 x 6-3/16 x 20-7/8	35 est			
Control Decoder C-2982	5-1/2 x 12-3/4 x 3-7/16	15 est	UPX-6	15x11x21	77
Coder Beacon KY-166	19-1/2 x 8-1/2 x 20-13/16	52			
Inter-connecting Box J1672		15 est			
Total Weight		147			77

Note: KY-299 contains: 3MX-2825 Decoders, 1 Decoder Pulse, Power Supply MX-2824, and Rack MT-1570.

The system will supply independent decoding of Mark X SIF replies on Mode I, II, or III; the system is comparable with existing navy/airforce, airborne systems, and will provide challenge priority of the three modes, with a priority of Mode III over Mode I, and Mode I over Mode II. The system is similar to present IFF/SIF GPX-8 installed in CPN-4 Radar Unit.

5.1.3 SYSTEM III (Figure 5-3)

The following configuration contains the APX-7 interrogator responder and coder synchronizer KY-84, which is an improvement over the UPX-6 unit. The system also contains transistorized decoder control KY-364. The following general information describes the above-mentioned units:

APX-7 General Information: The unit transmits a peak power output of 2kw, compared to 1.5 kw peak power from the UPX-6, and is 25 lbs less weight. The following table shows the general electrical characteristics of the APX-6 Receiver, transmitter, Coder-synchronizer, and Power Requirements.

Receiver	
Tuning Range	1090 Mc to 1110 Mc
Intermediate Frequency	59.5 ±0.5 Mc
Wide Bandwidth	
6 db down	7.5 Mc minimum
50 db down	15.0 Mc maximum
*Narrow Bandwidth	
6 db down	2.0 Mc minimum
50 db down	4.0 Mc maximum
*Signal/Noise ratio	5:1 for r-f signal 85 db below 1 volt
+Signal/Noise ratio	5:1 for r-f signal 79 db below 1 volt
Image Ratio	50 db minimum
All other spurious responses	50 db minimum
I-F Pick-Up	70 db minimum
Positive Video Output	2 volts peak
Gain Time Control (GTC)	

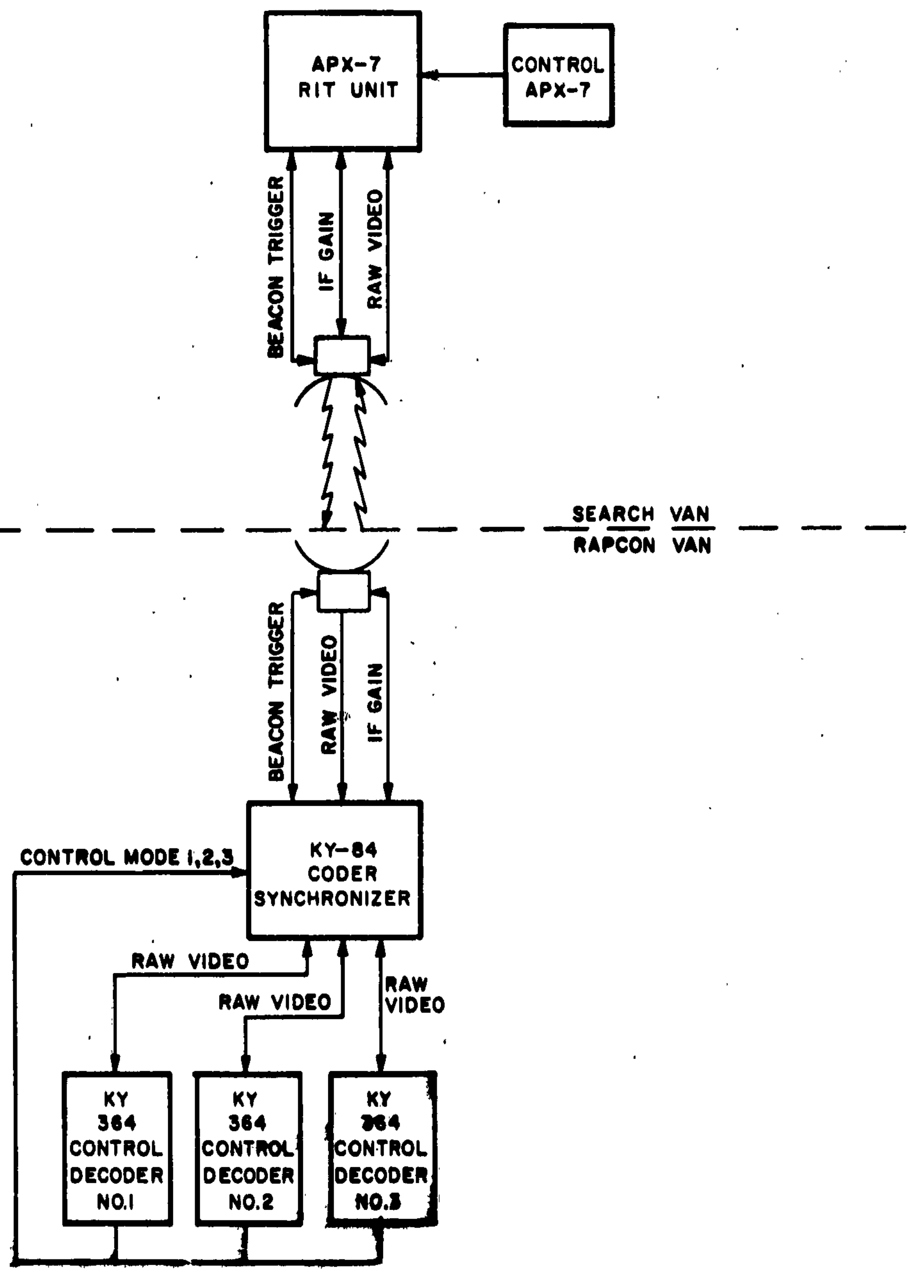


Figure 5-3. System No. 3

*Recovery Time	15 to 600 microseconds (adjustable)
+GTC Gate Duration	20 to 600 microseconds (adjustable)
Recovery Time	2500 to 6200 microseconds (adjustable)
Transmitter	
Tuning Range	1010 Mc to 1030 Mc
Peak Pulse Power Output	2000 watts minimum (1000 watts above 35,000 feet)
Pulse Pair Transmission Rate	145 to 320 per second
Pulse Pair Spacing	
Mode 1	3 ± 0.2 microseconds
Mode 2	5 ± 0.2 microseconds
Mode 3	8 ± 0.2 microseconds
Transmitter Pulse Shape	
Rise Time (10% - 90%)	0.2 microseconds
Duration (50% points)	0.7 to 1.2 microseconds
Decay Time (90% - 10%)	0.4 microseconds maximum
Coder Synchronizer	
Input Pulse	
Polarity	Positive
Duration (50% points)	0.3 to 20.0 microseconds
Rise Time (10% - 90%)	0.3 to 5.0 volts, within 0.2 microseconds
Reception Rate	145 to 3000 per second
IFF Video Output Signal to Radar Indicator	
Polarity	Positive
Amplitude	2 to 6 volts
Impedance	100 ohms nominal

Input Power

Nominal Input Power	115 volts, ac, 380 to 420 cycles, single phase, 60 watts
	115 volts, ac, 320 to 1760 cycles, single phase, 450 watts
	26.5 volts, dc, 0.3 amperes

*RT-261/APX-7 Only

+RT-261A/APX-7 Only

System III contains the following components:

Nomenclature	Form Name	Total
Interrogator Responder APX-7	Receiver/Transmitter	1
Coder Synchronized KY-84	Encoder	1
Video Decoder-Control KY-364	Decoder-Control	3

System Weight and Size

Rapcon Location	Inches H/W/L	Wt. in lbs	Radar Van	Inches H/W/L	Wt. in lbs
Encoder KY-84	7-13/16 x 10-3/4 x 19-11/16	37.5	APX-7	7-13/16 x 10-3/4 x 19-11/16	52
Decoder/Control KY-364	8-1/4 x 5-5/8 x 10	10.0			--
Total Weight		67.5			52

5.1.4 SYSTEM IV

System 4 contains the following equipment: (Figure 5-4)

(a)	APX-60 Interrogator	1
(b)	Coder-Synchronizer (Part of APX-60)	
(c)	Control-Decoder KY-364	3
(d)	Control Panel APX-60	1

<u>System Weight and Size</u>

Rapcon Location	Inches W/H/L	Weight in lbs.	Search Van	Inches W/H/L	Weight in lbs.
Decoder-Control KY-364	5-3/4 x 10-1/8 x 6-5/8	7.0	APX-60	10-3/4 x 7-3/4 x 19-3/4	50
			Control Box	5-3/4 x 3-3/8 x 4-11/16	2
Total Weight		21.0			52

General. The following general information contains the electrical characteristics of the APX-60:

Contents;		
	Transmitter	(2 modules)
	Receiver	(1 modules)
	Power Supplies	(3 modules)
	Coder-Synchronizer	(2 modules)
	Case	
	Control Box (separate from interrogator proper)	

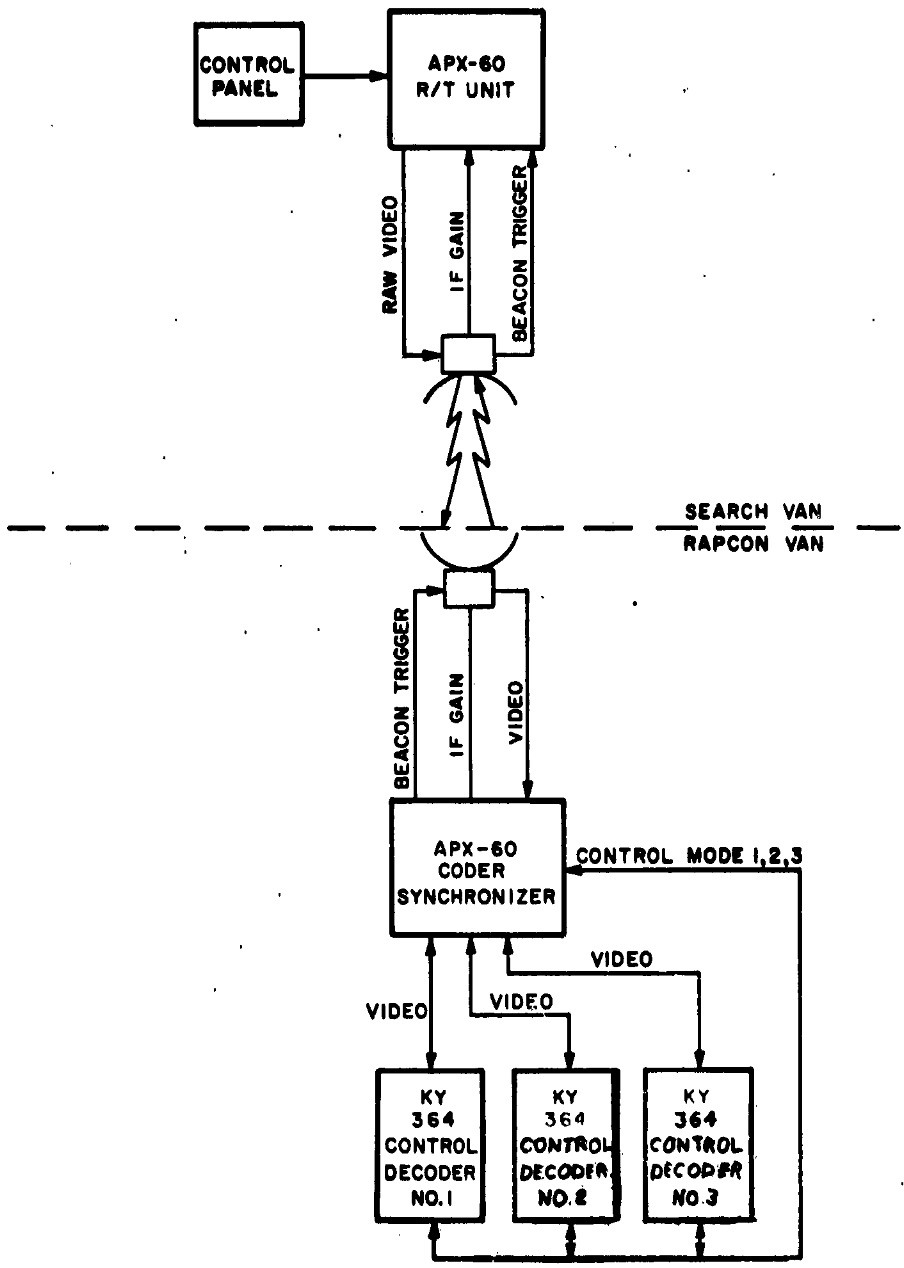


Figure 5-4. System No. 4

Input Power Reliability	115 V, 400 cps; single phase; (dc power derived from this) Reliable operating life of at least 1500 hours without removal for bench servicing. Minimum total operating life of 6000 hours with reasonable servicing and replacement of parts.
Power Output	5 kw - 10 kw; capable of being reduced to 1 kw - 2 kw as desired. Equipment designed to operate with optimum performance for 500 hours. Power output not reduced by working into a VSWR of 1.75:1.
Duty Cycle	Up to 0.01
Receiver Frequency	1090 Mc (adjustable from 1070 Mc to 1130 Mc)
Transmitter Frequency	1030 Mc (adjustable from 990 to 1050 Mc)
Frequency Stability	±500 kc
Receiver Tuning	Adjustment of five tuning screws
Transmitter Tuning	Adjustment of capacitive stubs
Noise Figure	Less than 9 db
Dynamic Range	In excess of 50 db
Pulse Characteristics (SIF)	
Duration	0.5 to 1.0 μsec with 0.75 being nominal
Rise Time	0.1 μsec or less
Decay Time	0.15 μsec or less
Amplitude Variation	Nor more than 5% variation over a 1 sec period
Pulse Shift	±0.1 μsec
Pulse Train Droop	Less than 10% from first to last pulse
Transmitter Delay	Less than 1.0 μsec
Local Oscillator Frequency Stability	±500 kc
Receiver Bandwidth	Greater than 9 Mc at 3 db down; less than 18 Mc at 40 db down Sensitivity curve flat to ±1 db

Intermediate Frequency	60 Mc nominal
Receiver Sensitivity	-91 dbv to -94 dbv
Receiver Gain	Greater than 110 db
Image Rejection	In excess of 60 db
IF Pickup	IF frequency attenuation measured at the "Antenna" jack less than 70 db
Band Rejection	At 15 Mc from center frequency, response to any signal greater than 60 db below response at center frequency.
Gain Time Control	Holds receiver gain at least 75 db down from normal sensitivity level. When triggered, gain rises from 75 db down to an adjustable value between 20 and 40 db below normal sensitivity within 15 μsec. Gain then continues to rise according to 1, 2, or 3 below. (1) The gain rises to within 3 db of normal sensitivity in a period adjustable from 400 to 2400 μsec. (2) The gain rises to within 3 db of normal sensitivity in a period adjustable from 20 to 600 μsec. (3) NO GTC. The gain rises from 75 db down to within 3 db of normal sensitivity in 25 μsec. When the GTC is disabled, the receiver must recover to within 20 db of normal sensitivity in not more than 10 μsec and to within 3 db in not more than 15 μsec.
Receiver Delay	Not to exceed 0.4 μsec
Video Output	Pulse amplitude level adjustable over the range of 1.5 to 2.5 volts.
Video Fidelity	Standard reply signals not exceeding -20 dbv and within the range of 3 to 50 db above normal sensitivity exhibit no degradation of rise and decay time, less than 0.05 μsec shift of spacing of any reply train, and pulse width increase not exceeding $(t_r \pm t_d)/2=1.0$ μsec. Also, interleaved trains spaced 0.7 μsec and having any level differential from 0 to at least 40 db are received with less than ±0.05 μsec pulse position shift within either train.

System IV contains the APX-60 interrogator and the KY-364 video decoders. The coder synchronizer unit is a part of the APX-60. For the system to function as requested, the coder-synchronizer unit will have to be removed and installed in the RAPCON van. Another approach, without any change to the microwave assignment and equipment, is to tag the Mode I, II, and III row video coming from the search van, and add a box designed to separate the three row video signals and place them on the correct line, Mode I, II, III, to the video decoder. The best approach, since the microwave is defined, is to remote the coder-synchronizer to the RAPCON.

SUMMARY: All four systems will meet the requirements of the EMS system. System I and II are by far the largest in size and contain the greatest weight. Both systems are available at the present time. Between the two configurations, System II is the most desirable. System III has the advantage of an all transistorized decoder-control unit; also the transmitter/receiver unit is smaller in size and weight than System I and II. The peak power output of System III is 2000 watts compared to Systems I and II, which have 1500 watts. System III is a qualified system and is in use today. System III rates highly over I and II in size and weight. The control-decoder units will be located on the indicator units in the same space required for the control panel only of System I and II. The only other space required will be for the coder-synchronizer which is smaller in size than the coder-synchronizer in System I and II.

System IV is the most advanced state of the art system of the four systems. It has a peak power output of 12,000 watts, is transistorized, and has a total weight of 73-lbs which is less than the weight of the UPX-6 alone. The APX-60, however, is not available at the present time. The estimated lead time is July 1962. The decoder-group is available at the present time. System IV is by far the most advanced of the

four systems mentioned and is recommended above Systems I, II, and III. It should be noted that the interrogator unit of System IV can be moved into System III by replacing the APX-7 and KY-84 coder synchronizer units as a field change if desired, since the control-decoder group is the same in each system.

5.1.5 CONCLUSION

Certain combinations of the four systems could be made to work together, for example, the AN/UPX-6 could be used in system No. 3, Figure 5-3, in place of the AN/APX-7. Also there are other systems available to satisfy the requirements of the AN/TPS-35 system.

5.2 GENERAL PERFORMANCE AND FUNCTION OF KY-364/APX VIDEO DECODER/CONTROL

The purpose of the KY-364/APX is to process input video from the recognition radar and to provide a decode output signal for visual presentation on an indicator unit. A decode output signal is available for display only when the input video represents an SIF code which is in agreement with the present code of the KY-364/APX. Display of a decode output, therefore, indicates a true target reply and serves to identify friendly aircraft. The front panel of the KY-364/APX contains all controls necessary to establish a preset code in the three operating modes which are utilized within the IFF-SIF beacon system.

5.2.1 FUNCTION

The KY-364/APX receives and processes the radar video which represents SIF coded replies from target transponders. Delay lines and diode logic are used to analyze the coded replies in order to identify a true or false target. The delay lines provide the means for presenting a complete SIF pulse coded train to the diode switching circuits in parallel form. The SIF coded reply consisting of a multiple pulse-position train with a duration of 20.3 microseconds is examined by

diode logic for the presence or absence of pulses. The diode logic matrix, controlled by front panel switches, is preset to require the presence of certain pulses and the absence of others. Target replies must then be in agreement with the preset code, containing the required pulses on the code train and no others, in order for the KY-364/APX to generate a decode output signal. Target replies that are not in agreement with the present code are rejected and no decode output signal is generated.

Besides the passive decode function of the KY-364/APX, a bracket output and the code video are provided for display. The KY-364/APX generates a bracket output signal if two pulses (referred to as bracket pulses) spaced at 20.3 microseconds are received. The bracket pulses represent the first and last pulses on a SIF code train. The bracket output is not affected by the presence or absence of other pulses on the time base between bracket pulses. The code video is always available as an output from the KY-364/APX. It appears at the end of the delay line in series form delayed 40.6 microseconds from the input. One of the outputs – decode, bracket or code video – may be selected by a front panel switch for display on the associated indicator.

The KY-364/APX decodes interleaved code trains which represent the pulses of one code train shifted within limits from the nominal positions established by a second code train. It rejects all code trains which are considered garbled. The degarble feature of the KY-364/APX serves to detect the presence of garbled code trains. A garble condition may result from the interrogation of two or more targets which are at approximately the same range and bearing. The subsequent replies from these targets could be arranged in such a manner as to create a true code from otherwise false individual targets, resulting in an erroneous decoding operation. Under certain conditions,

multipath reception may also create garbled replies. Detection of garbled replies is the function of the garble circuit. This circuit disables both the passive decode output and the bracket output when garbled replies are received.

The Ky-364/APX uses plug-in modular sub-assemblies for all circuit sections and delay lines. The sub-assemblies are non-reparable items, encapsulated with an epoxy resin. They are built on printed circuit boards and have integral printed circuit connectors. Test jacks located on the top of each sub-assembly are readily accessible when troubleshooting the instrument. An edge-lighted front panel is used on the KY-364/APX.

ELECTRICAL CHARACTERISTICS

Input Signal:	Mode 1, 2, or 3 replies consisting of multiple pulse trains in SIF codes.
AMPLITUDE	2 ± 0.5 volts
PULSE DURATION	0.35 - 0.55 microsecond
POLARITY	Positive
PULSE SPACING	Multiples of 0.45 microsecond within a train of 20.3 microseconds as measured from leading edges of bracket pulses.
INPUT IMPEDANCE	75 ohms (terminated); 3600 ohms shunted by 22 mmfd. (unterminated)
Output Signal:	
AMPLITUDE	2 ± .5 volts across 75 ohms
PULSE DURATION	0.45 microsecond (nominal)
POLARITY	Positive
DECODE AND BRACKET PULSE	Single pulse output for each input code train

CODE (delayed code video)	Same waveform as input video but delayed 40.6 microseconds
Power Requirements:	20-29 volts dc
	400 ma at 24 volts

5.2.2 PERFORMANCE AND FUNCTION OF EQUIPMENT

GENERAL - The Video Decoder KY-364/APX is a passive decoding instrument which is designed to process radar video in order to identify challenged aircraft. It furnishes a decode output signal, signifying a true coded reply, for visual presentation on an associated indicator unit. This decode signal is generally displayed in coincidence with the search radar blip, thereby visually identifying detected aircraft. The KY-364/APX rejects a false coded reply, and a no decode signal is displayed. The passive decoding function is based on the SIF code system previously discussed. A bracket output signal may also be supplied by the KY-364/APX, independent of the passive decode signal, if target replies contain bracket pulses. The input code video is always passed by the KY-364/APX and is available as an output. Any one available output - decode, bracket, or code video – may be selected for display by the OUTPUT switch on the front panel. There are no provisions for simultaneous operation in more than a single mode possible. This means that the operator must select input video – either Mode 1, 2, or 3 – and also select a desired output signal.

A. SIF Codes

The SIF code system uses a multiple pulse train which is established on a 20.3 microsecond time base. The 20.3 microsecond pulse train as transmitted by target transponders represents a binary code in which the presence or absence of pulses at a particular interval on the time base is the criteria for a true or false code. Each mode of operation is established as a slightly different binary code. The

presence or absence of information pulses at a particular interval on the train is a requirement established by the preset code in the KY-364/APX.

The time between bracket pulses is divided into thirteen information pulse positions at intervals of 1.45 microseconds. The position midway between the bracket pulses (number 8) is not used in SIF codes. The remaining twelve positions are used for pulse coding. These twelve information pulses are each identified with a time position spaced from the first bracket pulse. They are divided into four groups (A, B, C, D) with each group containing three pulses. The pulses within each group are spaced at 2.90 microsecond intervals and are identified by numbers 1, 2, and 4. An SIF code number is then derived as a two or four digit number which indicates the pulses required by group and number. That is, the first digit of an SIF code will designate the pulse or pulses in A group; the second digit, the B group; the third digit, the C group; and the fourth digit, the D group. The C and D pulse groups are only used in Mode 2, 12 pulse codes. Therefore, a four digit code number is assigned. A two digit code number is assigned for Mode 1, Mode 2, and Mode 3 operation. For example, a preset SIF code numbered 12 for Mode 1 requires pulses A1 and B2, plus the two bracket pulses which are always required. Any reply code train that does not have these pulses or has additional pulses is a false code and will be rejected by the KY-364/APX. A Mode 3 code numbered 56 will consist of pulses A1, A4, B2, and B4; a Mode 2 (6 pulse) code numbered 3122 will consist of pulses A1, A2, B1, C2 and D2.

5.2.3 FUNCTION OF OPERATING CONTROLS

All controls necessary to establish a decoding function are located on the front panel of the KY-364/APX. Operating power which is furnished from the aircraft 28 volt dc supply is controlled by the OUTPUT

switch on the front panel. Figure 5-5 shows the location of front panel controls.

5.2.4 DELAY LINE

Three delay lines are used in the KY-364/APX and are designated the before A3, decode A4, and garble A9 lines. The before and decode delay lines are identical interchangeable units, each consisting of two sections and providing 20.3 microseconds delay. The garble line consists of a single section for a delay time of 10.15 microseconds. Each line is a lumped-constant delay line which is tapped at intervals of 1.45 microseconds corresponding to the information pulse positions. The pulse positions may be multiples of either 1.45 microseconds or 2.9 microseconds. The delay line is maintained at a 12-volt dc reference level. Since the point of application of the reference voltage is the ac ground of the delay network, this voltage must be supplied from a low impedance source. Line amplifier circuits are provided to compensate for slight signal attenuation caused by the line. The amplifier circuits restore signal level to the original input amplitude and also provide isolation between the line sections. The total representative delay from signal input to decode delay line output is 40.6 microseconds.

5.2.5 GARBLE CIRCUIT

The garble circuit including the garble delay line serves to detect garbled code trains and then to disable the bracket and passive decode outputs. It performs this function by examining a period of 18.85 microseconds before and after each input code train at intervals of 1.45 microseconds. If a pulse appears within this interval and if it is spaced 20.3 microseconds from any pulse on the basic code train, the code train is considered garbled. This could result from any one of several arrangements of input code trains or signals. For example, overlapping code trains, the first or last pulse of an adjacent code train,

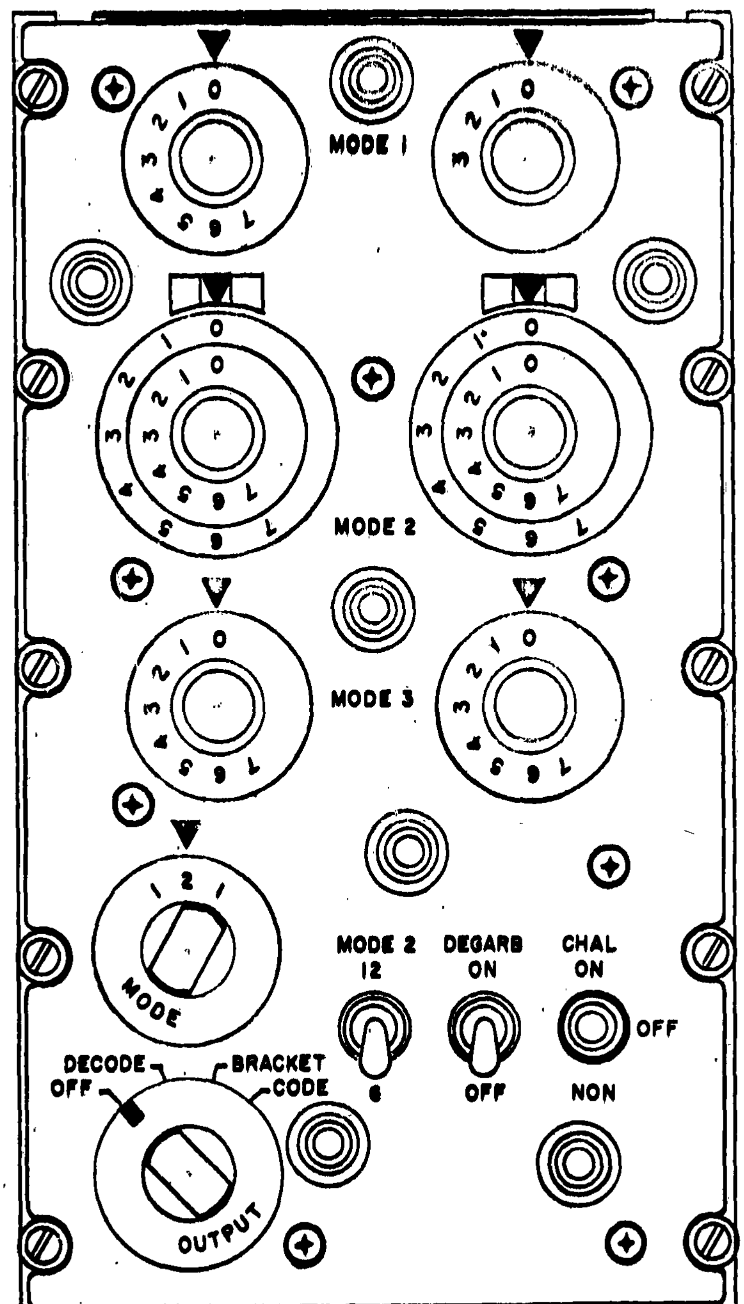


Figure 5-5. Front Panel, Video Decoder KY-364/A PX

or simply a random signal appearing at the proper time could represent a garbled condition.

The criteria then for a garbled reply is the presence of a preceding or following pulse which, in effect, forms a second pair of bracket pulses within the specified time interval. This time will be some multiple of 1.45 microseconds. The resulting output of the logic AND gate is amplified and shaped in the delay line drive circuit. This signal is impressed on the unterminated garble delay line. As it travels down the line, the signal appears consecutively at each tapped segment of the line and is reflected from the unterminated end to again appear at each tap. The tapped signal is passed through the OR gate to the amplifier circuit. Consequently, an inhibit signal is generated for each tapped signal. The inhibit signals, positioned at 1.45 microseconds intervals for a period of 18.85 microseconds, are applied to the bracket circuit. The decode time will begin at some multiple of 1.45 microseconds within an 18.85 microseconds interval from the application of the signal to the garble delay line. One of the inhibit signals will then appear in coincidence with the triggering of the passive read gate and bracket output signals in the bracket circuit. It will effectively cut off that stage in the bracket circuit – the multivibrator stage – which generates the read gate and bracket output.

It should be noted that inhibit signals are generated for all bracket pulse inputs, including coded replies from a single target that are not garbled. However, for single code train inputs, an inhibit signal will not appear in coincidence with the triggering of the passive read gate and bracket output. It is therefore ineffective. With single target replies, the inhibit signal will always precede or follow the triggering of the read gate and bracket output by 1.45 microseconds. This delay is established by the garble delay line and by the MODE 2-6/12 switch.

A. <u>Garble Circuit Controls</u>

Two switches mounted on the front panel of the KY-364/APX are provoded to control the garble circuit operation. The DEGARB switch is used to turn the garble circuit on or off. Consequently, outputs from the logic OR gates are effectively shorted. In the "on" position, bias voltage is removed and the amplifier stages may be activated by incoming signals. The MODE 2-6/12 switch is used to activate or deactivate the CD amplifier stage during MODE 2 operation only.

SECTION 6.

UHF COMMUNICATIONS GROUP

6.1 INTRODUCTION

A single channel UHF communication set should be included in the AN/TPS-35 to provide air-ground-air voice transmission and reception. The system could provide the required communications between the radar and any controlled aircraft when the AN/TPS-35 is deployed singly. The unit should have provisions for selecting 1750 individual operating channels and a guard band monitor channel that envelopes the frequency range of 225 to 399.9 Mc. Figure 6-1 is a block diagram of a UHF communication set.

6.2 TECHNICAL DESCRIPTION

The communication set (UHF) in Figure 6-1 is a Collins 618A-13. Received signals in the frequency band of 225 to 399.9 Mc are converted to an IF band, extending from 20.0 to 29.9 Mc, by mixing with the output of a frequency spectrum generator. The 20 to 29.9 Mc IF signals are again converted by mixing with the output of a variable frequency oscillator. The 1.85 Mc output signals are amplified, detected, and applied to the earphone or speaker assembly.

A parallel operated guard band channel is available for providing continuous monitoring. A separate crystal controlled oscillator generates the local oscillator signal for the guard channel. The frequency tuning limits of the guard band channel are 238 to 248 Mc. A crystal is supplied for operation on 243 Mc.

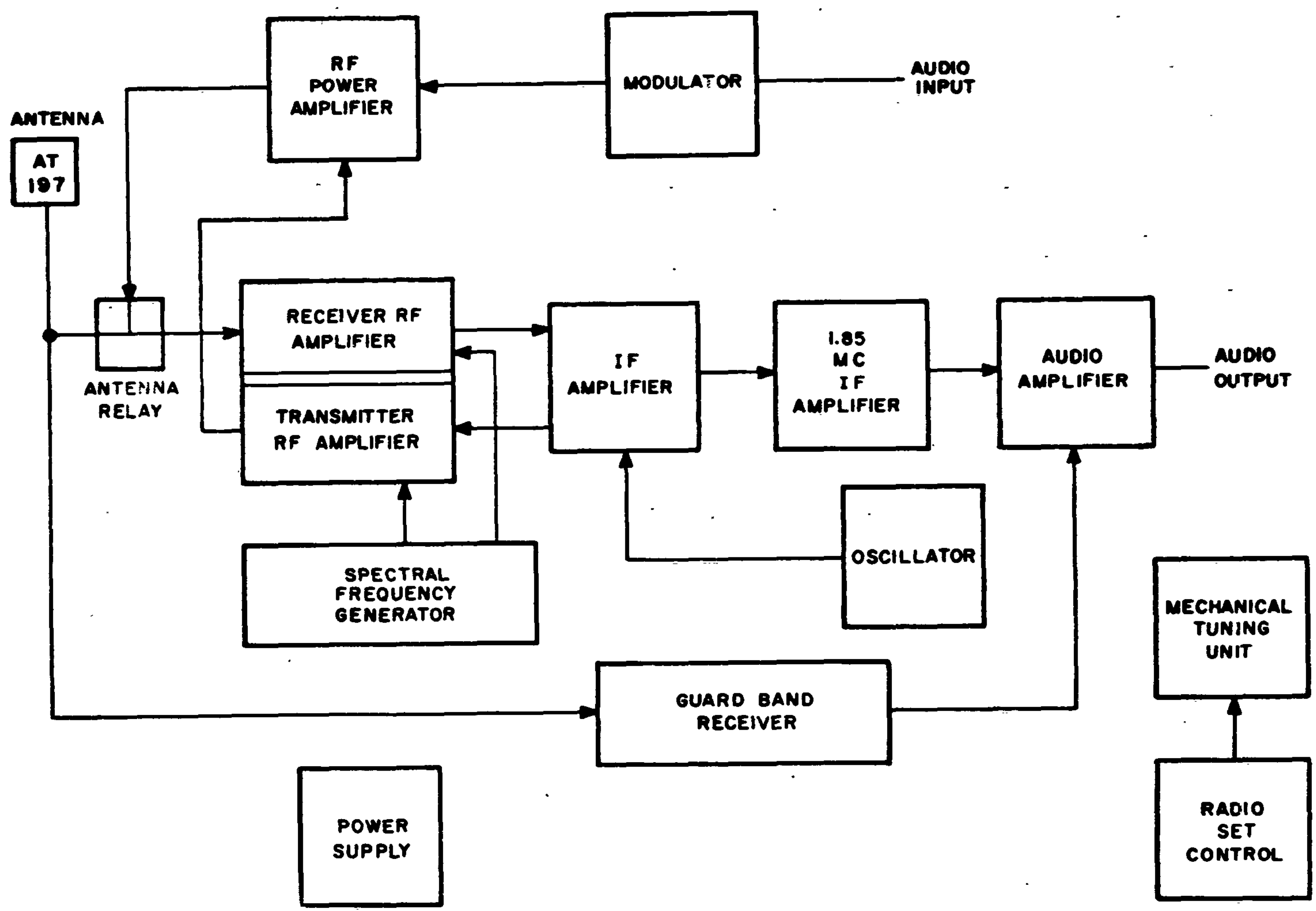


Figure 6-1. UHF Communications Set, Block Program

The transmitted frequency is dependent upon the frequency output of the 21.85 to 31.75 Mc local oscillator. The oscillator output signal is amplified and mixed with the output of the spectrum generator. The UHF output is filtered and amplified to approximately 20 watts in an RF power amplifier. An input from the modulator unit amplitude modulates the generated carrier frequency.

A remote radio set control box, located near the radar indicator front panel, provides manual control of the 1750 channels by four manual rotary switches. A single rotary switch provides selection of any one of eighteen pre-set channels. Volume control and a mode switch are also available at the remote control box.

AVC, squelch, noise limiting, and a sidetone generator for monitoring purposes are a part of the receiver section.

An internal power supply converts the 400 cps input power to the desired ac and dc operating voltages. 28 volts dc is obtained from the TPS-35 shelter 28 volt dc buss.

6.3 MECHANICAL DESCRIPTION

(a) The approximate physical size of the communication set is 11 inches wide by 8 inches high by 20 inches deep. The case is of aluminum construction.

(b) The weight of the unit is nominally 52 pounds.

(c) An AT-197 UHF antenna should be attached to the top of the shelter. A support could be provided to mount the UHF antenna higher than the maximum height of the radar antenna reflector.

6.4 MAINTAINABILITY AND SERVICEABILITY

The transceiver unit is housed in a single enclosure. An internal blower supplies the required cooling.

The sub-assemblies in the transceiver unit are of plug-in modulator construction to provide ease in maintenance and replaceability. There are 13 modules in the transceiver unit.

SECTION 7

SHELTER REQUIREMENTS

7.1 SELECTION OF SHELTER TO MEET REQUIREMENTS

The standard S-141 shelter is a lightweight van which can either be furnished or is in production. This shelter is made to conform to MIL-S-52059.

Diagrams are included (see Figure 7-1; 7-2; 7-3) to show the relative position and size of the search radar, the workspace required, and the storage space allocated for the different search radar and microwave accessories.

The size and weight parameters are important factors in choosing a suitable shelter. Also, this shelter can be and is capable of having leveling jacks attached is capable of the 463L Cargo Handling adaptability and is provided with external shock pads.

This shelter can be towed, dragged, lifted, truck-carried, or plane delivered. It has good insulating qualities and has a fairly low coefficient of heat transfer.

The air conditioner and power supply are external when in operation, but these units can be stored internally for transport condition.

The shelter size is

	External	Internal
Length	138 3/16 in.	134 in.
Width	80 1/16 in.	76 in.
Height	77 15/16 in.	73 1/2 in.

7.2 MODIFICATION OF SHELTER AND RACKS REQUIRED

The S-141 shelter should be modified to incorporate the mounts for the antenna structure including a reinforced roof in the areas where the bases of this structure are terminated in the mounts. These terminations should be thermally insulated from the shelter. The roof reinforcement in this location should be partially derived from the vertical racks provided to support the antenna pedestal and rack mount, the receiver, and main power supply groups. A manually operated hoisting device should be provided on the roof above this area to facilitate lifting of the antenna pedestal into place.

The microwave units are rack mounted to the right of the shelter entry door. The aluminum alloy rack provides for two columns of 19-inch wide equipment panels having fastener spacing on standard 1 3/4-inch centers.

The entire double rack is shock mounted to the floor and ceiling and arranged to hinge 90° on the left pair of mounts to provide assembly and maintenance access. Interconnecting cabling amoung units is installed in the rear of the racks and has disconnecting fittings for individual equipment removal.

The waveguide is routed through the attenuator at the top of the left hand rack section. A flexible waveguide section between the attenuator

and the antenna mount permits hinging of the entire equipment rack assembly. The attenuator chassis panel contains a transparent hinged door permitting visual inspection and adjustment of the attenuator.

A waveguide external to the shelter connects the interior waveguide to the antenna upon system assembly. The antenna is mounted on a mast at the corner of the shelter. The antenna mount assembly on the mast provides for the azimuth and elevation adjustments required and the tortional and flexural stiffness necessary to withstand the wind and ice conditions. A flexible waveguide to the antenna permits the angular adjustment required. The antenna assembly and mast are stored within the shelter for transport.

The following shows the leading particulars of the microwave equipment:

Name	Number	Dimensions H	W	D	Wt	Amps	W
RF Attenuator	1	$4\frac{1}{2}$	$10\frac{1}{2}$	8	$5\frac{1}{4}$	--	--
Rack, Door Frame	1	--	43	--	--	--	--
Air Duct	1	$66\frac{1}{2}$	$1\frac{1}{2}$	$6\frac{1}{4}$	--	--	--
M/W RF TX	2	7	18	$14\frac{1}{2}$	41.7	2.17	260
M/W RF RX	1	7	18	$14\frac{5}{8}$	35.5	1.75	210
RF Power Supply	1	7	18	$16\frac{1}{2}$	60.0	2.5	300
Blower	1	$8\frac{3}{4}$	18	$10\frac{5}{8}$	15.0	.05	6
Order Wire	1	7	18	$10\frac{1}{4}$	26.8	0.75	90
VVT Multiplexer	1	$3\frac{1}{2}$	18	5	3.5	--	--
VT Multiplexer	1	$1\frac{3}{4}$	18	8	2.6	--	--
Demultiplexer & Trigger Generator	1	$3\frac{1}{8}$	18	5	5.0	--	--

Name	Number	H	D	Wt	Amps	W
Monitor Panel	1	$3\frac{1}{2}$	18	$5\frac{3}{4}$	--	--
SC Transmitter Frame	1	$5\frac{1}{4}$	18	4	--	--
SC Transmitter	3	$2\frac{5}{8}$	$8\frac{3}{4}$	$6\frac{1}{4}$	--	--
SC Receiver Frame	1	$5\frac{1}{4}$	18	4	--	--
SC Receivers	1	$2\frac{5}{8}$	$8\frac{1}{2}$	$6\frac{1}{4}$	--	--
VFC Frame	1	14	18	$17\frac{3}{4}$	--	--
VFC Receivers	9	$3\frac{7}{8}$	$4\frac{1}{8}$	$13\frac{7}{8}$	0.013	1.56
Power Distribution Panel	1	$3\frac{1}{2}$	18	$2\frac{1}{2}$	--	--
Multiplex Power Supply	2	$5\frac{1}{4}$	18	17	2.3	276
Antenna (4 ft)	1	$49\frac{1}{2}$	$49\frac{1}{2}$	29	--	--
Radome (4 ft) & Heater	1	50	50	$22\frac{1}{2}$	4.6	550

The weight breakdown of the shelter is the following:

RADAR SET & UTILITIES

Unit	Weight
Receiver	280
Transmitter	250
Main Power Supply	140
Modulator Power Supply	155
ECCM Kit	140
Echo Box	35
Indicator	205
Clock Set	10
Elapsed Time Indicator	20
M/W - Radar Junction Box	20

Unit	Weight
AN/UPM 98 Equipment	90
AN/UPM 98 Accessory Case	10
RACEP Unit	44
UHF Comm. Control Box	8
30 Days Spare Case	60
M/W Equipment	450
618 A-13 Chassis	52
KY-364 Chassis	10
UPX-6	77
Blowers: - Magnetron	15
- Transmitter	15
Waveguide, Oil Reservoir Magnetron, Tuner	100
Waveguide Links	50
Fire Extinguisher	8
ECCM Kit Control PAnel	15
Blackout Curtian	10

TRANSPORT ITEMS

Unit	Weight
Antenna Pedestal	255
M/W Antenna	100
RACEP Whip and UHF Antenna Package	35
Accessories Case	60
Misc. Items, Connectors, & Cables	500
Chair & Stool	30
TOTAL (estimated)	3249 lbs

SHELTER MODIFICATIONS

Unit	Weight
Work Bench	45
Storage Cabinet	25
Rec/Main Power Supply Rack	150
Transmitter/Mod. Power Supply Rack	80
AN/UPM-98 Racks	40
M/W Racks	110
Indicator & Console Rack	100
Junction & Circuit Breaker Panel	25
618A-13/KY-364 Mounting	40
Air Conditioning Ductwork	60
Oil Reservoir Bracket	5
Curtain Wall	40
Spare Magnetron Storage	6
Mountings for Transport Items	30
Assorted Bracketry	60
Wire, Lights & Convenience Outlets	120
Remote Junction Box	20
TOTAL (estimated)	956 lbs

Shelter (Basic)	1200
Modifications	956
Radar Set & Utilities	3249
TOTAL (estimated)	5405 lbs

7.3 ARRANGEMENT OF COMPONENTS DURING OPERATIONAL MODE

On the right as you enter the shelter (Figure 7-1) is a double rack, from floor to ceiling, of microwave equipment. Continuing along the right wall is a 4-foot long workbench which folds horizontally when in use. A partition crosses the width and height of the shelter, and behind this partition is the modulator transmitter, magnetron, tuner motor, waveguides, ducting to wall cut-outs to join to blower motors, modulator receiver and modulator power supply. Louvers are installed at the upper and lower levels of the partition. Four 3-inch by 3-inch aluminum posts or extrusions are permanently mounted vertically and form a rack to support equipment in one case but also reinforce the roof section which is to support the pedestal and antenna assembly.

Another floor to ceiling rack is mounted on the left side of the van. The rack is far enough away from the rear partition to have pull-out access to equipment mounted in the structural support rack. In this rack is mounted the electronic counter-counter measure equipment and a range-azimuth indicator. Below the indicator a shelf is provided, and beneath the indicator knee space is provided. To the side of the rack, a RACEP unit can be mounted and the azimuth-range control box is mounted for right hand operation.

The power entry panel is mounted on the upper left of the doorway, and inside the shelter behind this panel entry is the junction box and circuit breaker panel.

7.4 ARRANGEMENT OF COMPONENTS DURING TRANSIT MODE

On the right wall (Figure 7-2) between the microwave rack and the rear partition, a 4-foot diameter radome and its dish are wall mounted.

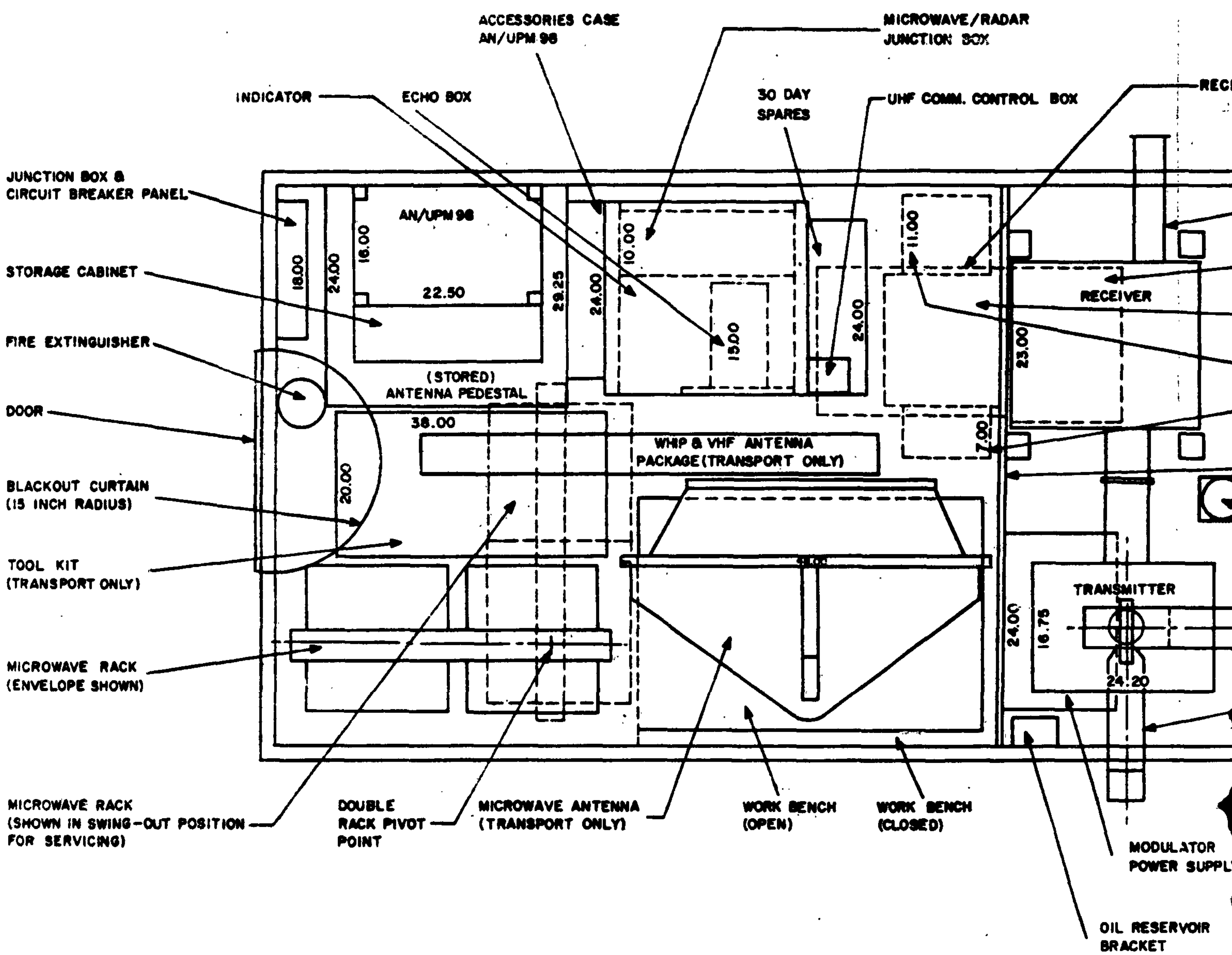


Figure 7-1. Plan View of Search Radar Shelter, Transport Configuratio

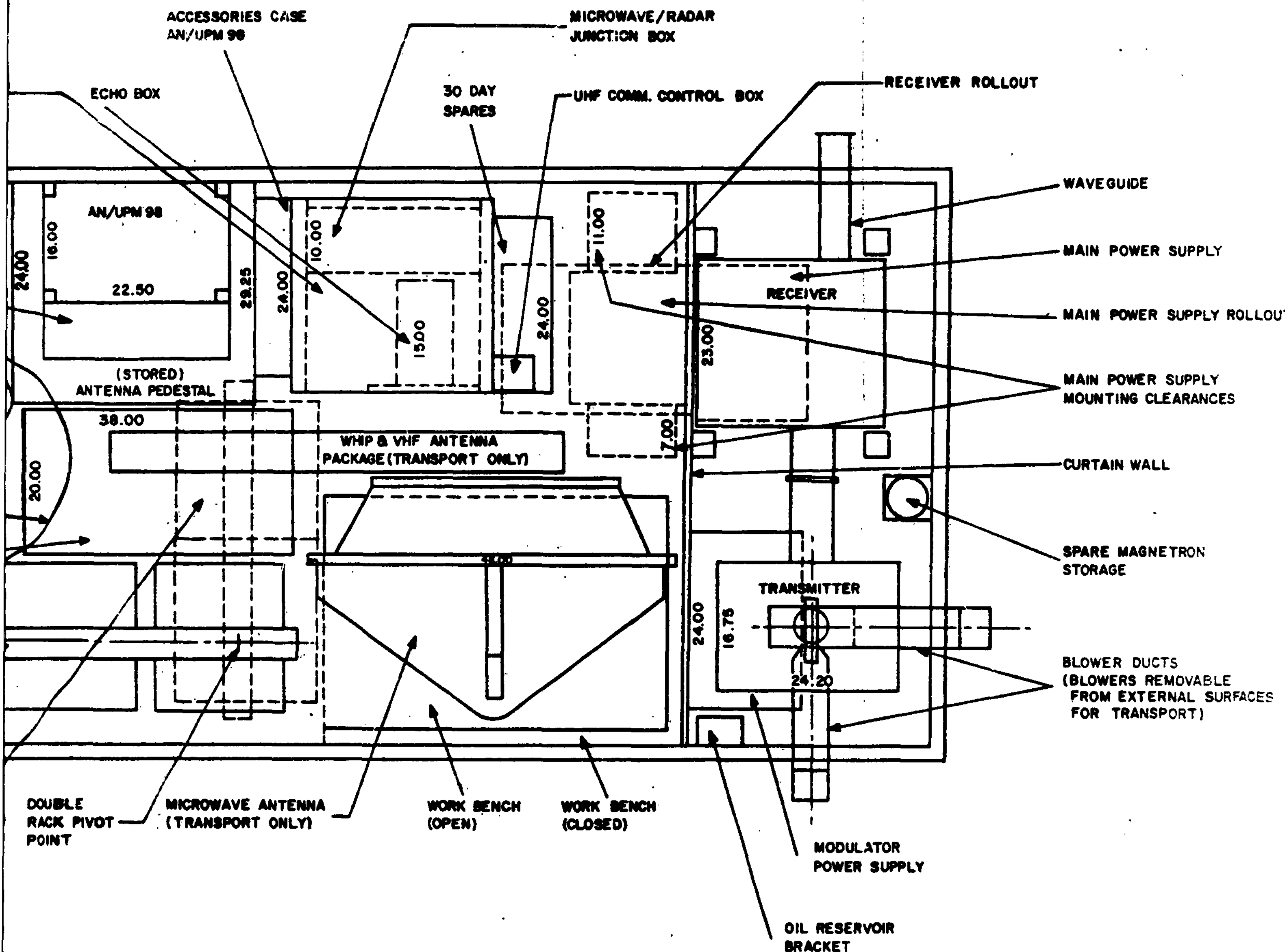


Figure 7-1. Plan View of Search Radar Shelter, Transport Configuration

1

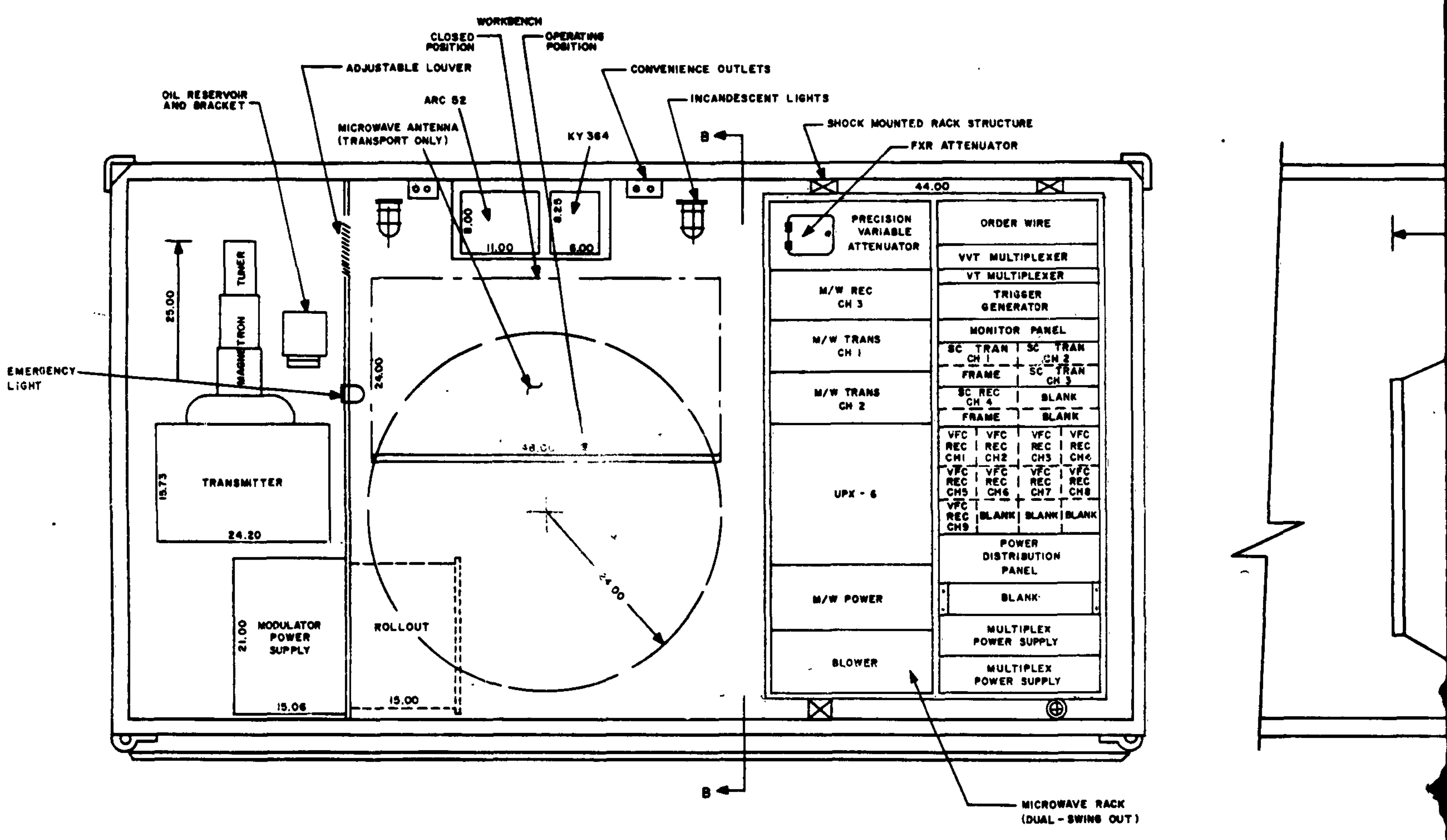


Figure 7-2. Right Elevation of Search Radar Shelter

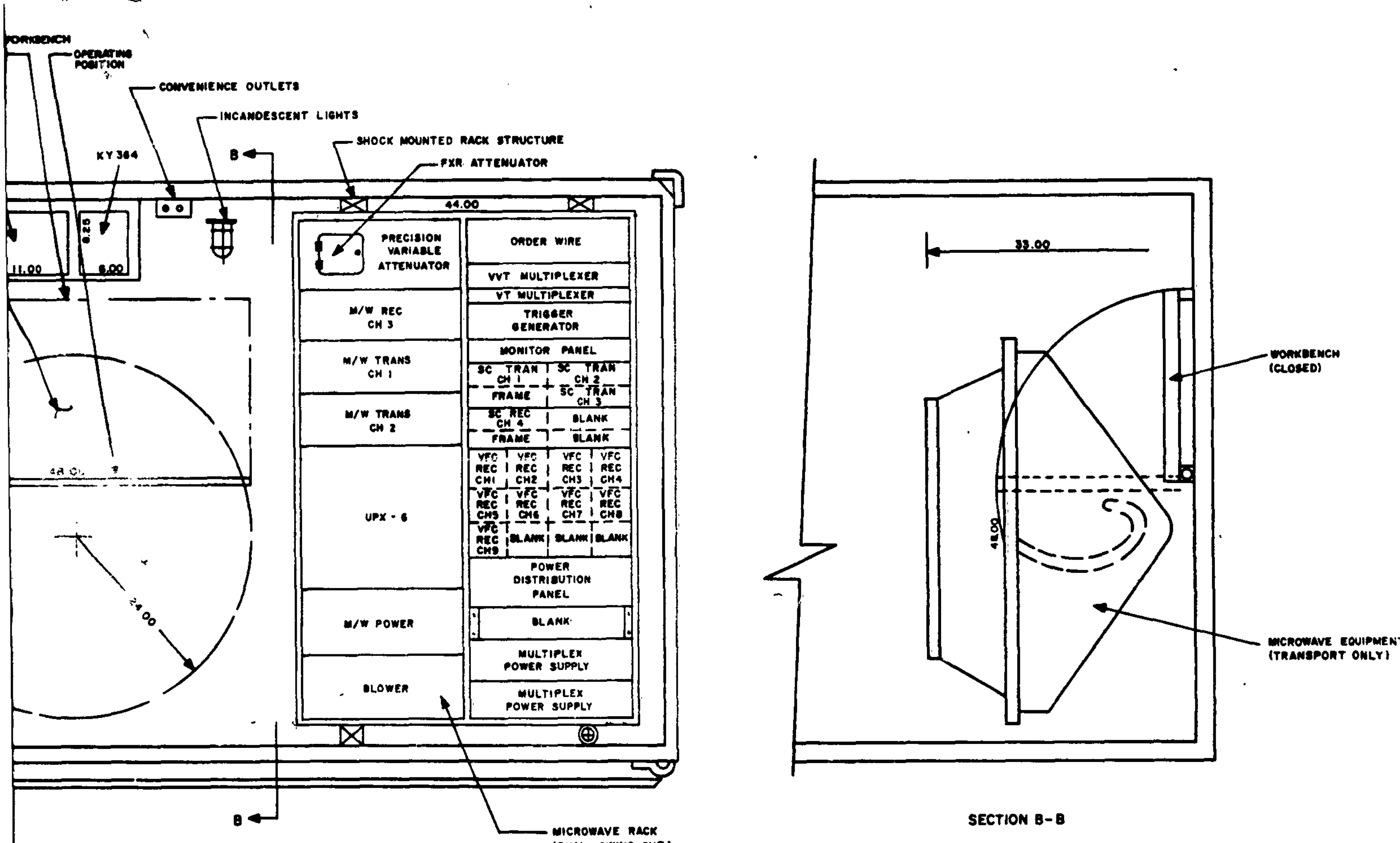


Figure 7-2. Right Elevation of Search Radar Shelter

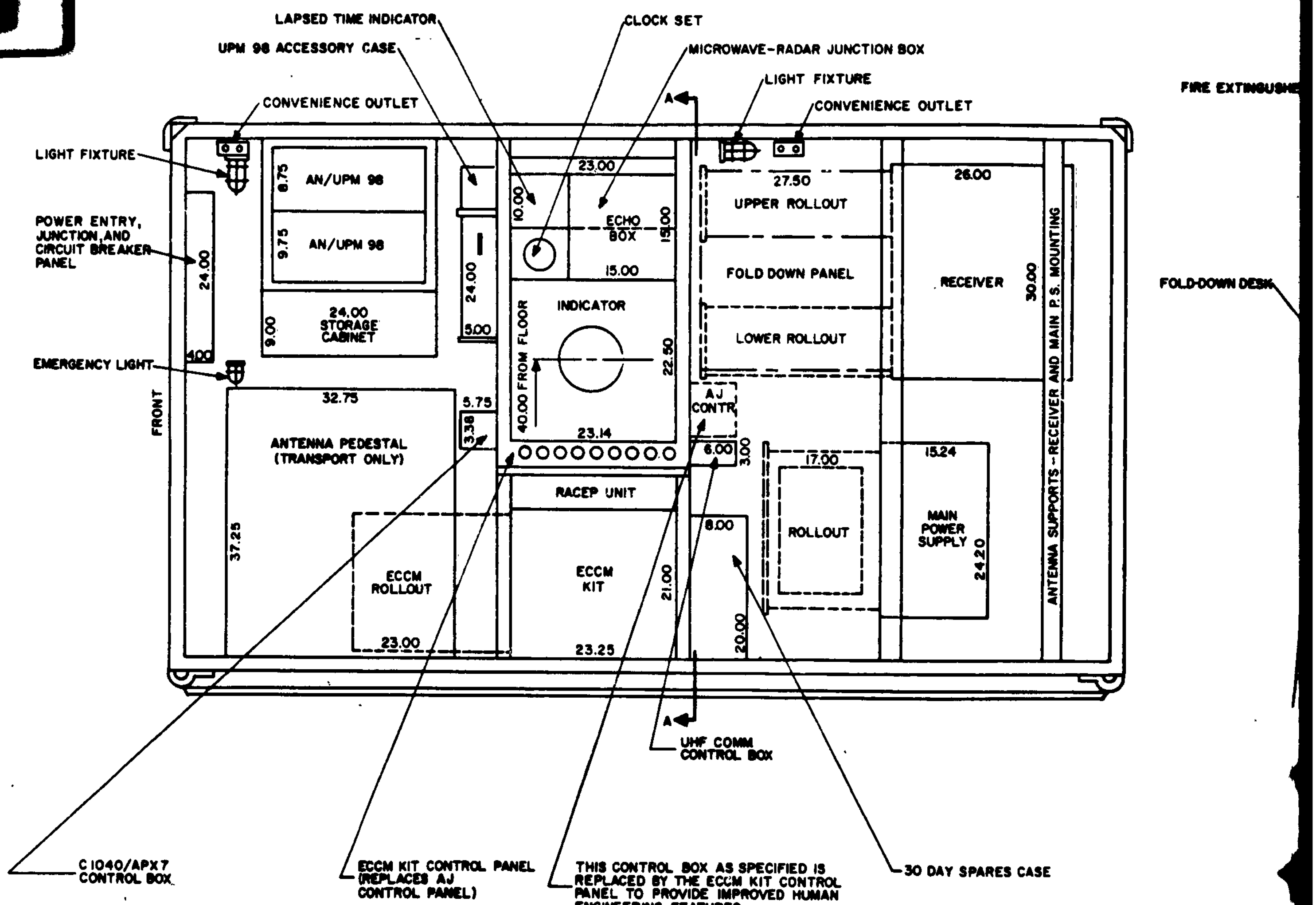


Figure 7-3. Left Elevation of Search Radar Shelter

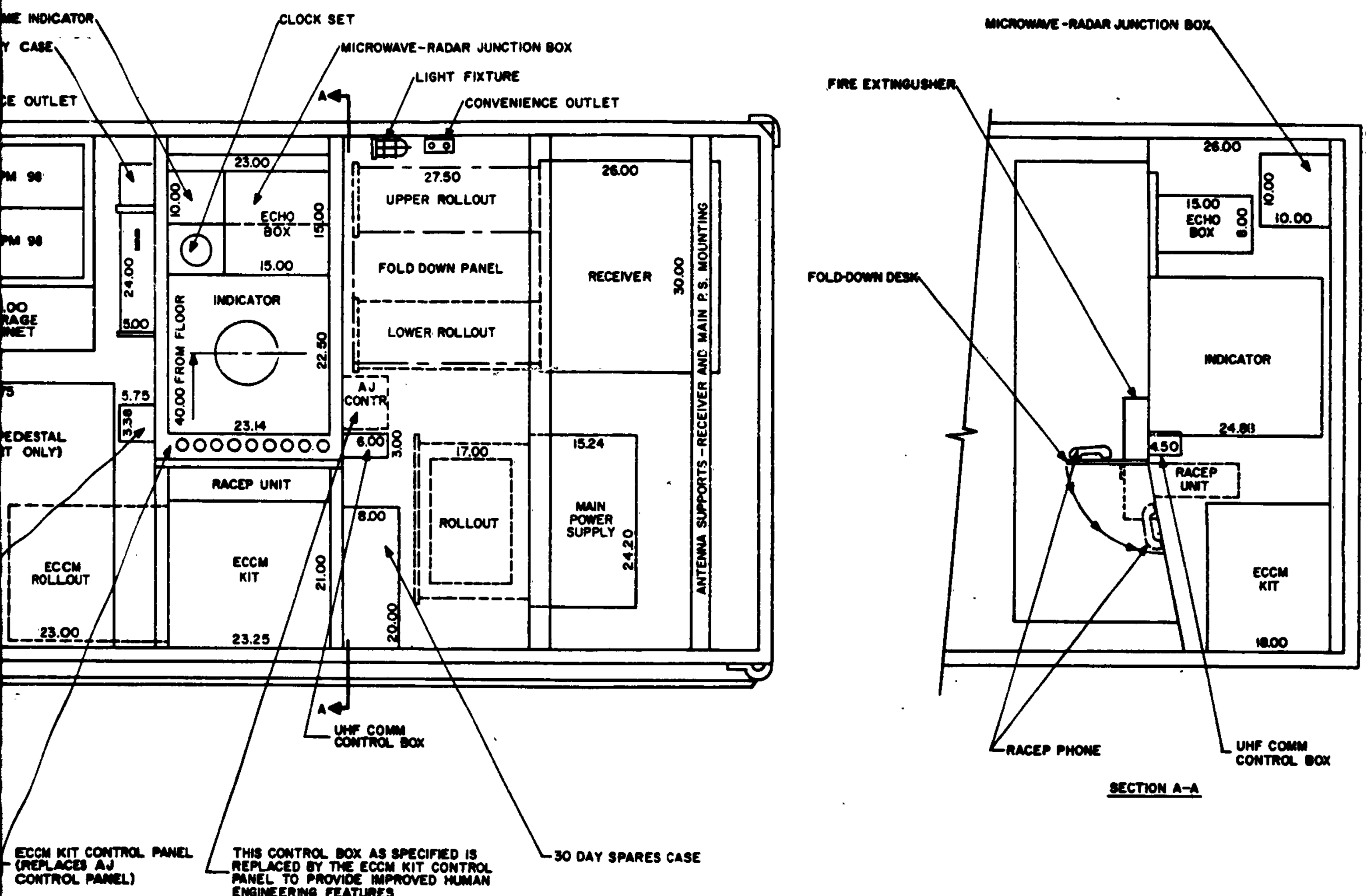


Figure 7-3. Left Elevation of Search Radar Shelter

On the left side (Figure 7-3) in the corner near the door the antenna pedestal is stored in a case and miscellaneous accessories are stored in a case above it.

Beneath the indicator can be stored the operator's chair. Leveling jacks are tied down to the floor in front of the door. Blower motors are stored inside. The microwave antenna section is also stored inside.

7.5 DETAILED DESCRIPTION OF STRUCTURAL DESIGN TO MEET REQUIREMENTS

The search radar shelter will be transportable by a C130A aircraft, helicopter, 2 1/2-ton cargo truck, and railway flatcar. The shelter meets the fordability requirements and can be towed over distances of 1500 feet on the skids provided. The skids are made of channel sections of formed aluminum alloy which is filled with a styrene foam with a set density designed for shock resistance and meets the flat drop, corner drop, and rotational drop test requirements. The construction is suitable for being rolled or supported anywhere along its length by a 2 inch pipe.

The shelter should be equipped with aluminum alloy structural rail members having a lip configuration and 10-inch center to center slot spacing as specified in MIL-P-27443B.

The floor should be covered with a non-skid cloth back, dielectric material, and should have drain provisions.

Wall openings should be provided in the rear and side wall for the transmitter and magnetron blowers as depicted in the Figure 7-1. Captive fasteners should be provided around the openings for securing the blowers to the outside and ducts to the inside. Hinged watertight covers should be provided to maintain watertightness in the transport condition.

Two additional wall openings should be provided for the radar and microwave waveguide runs. Means should be provided for maintaining watertight openings when the waveguide is assembled and installed through the openings for operation, and covers should be provided for all openings to maintain watertightness in the transport condition.

Two towing eyes, each capable of withstanding a lifting stress of 10,000 psi in any direction, should be provided on each end of the shelter at the base and should be within the aforementioned overall dimensions.

Lifting eyes should be provided at each top corner. These lifting eyes should each have a minimum ultimate strength of approximately eight times that necessary to support its equal share of the static weight of the loaded shelter or approximately 11,000 pounds.

A lifting sling should be provided for helicopter and crane transportation. This sling should also serve to guy the shelter to ground anchors when the radar set is in operation.

7.6 AIR CONDITIONER DUCT DESIGN

Referring to Figure 7-4 and 7-5, the rear wall should be equipped with two openings; one for the inlet air duct and the other for the output air duct. The upper opening is for entry cooling air and the lower to remove the heated air for recirculation. A partition separates the radar equipment from the work space and personnel positions.

This equipment supplies 80 to 85 percent of the heat load and this heat must be removed. Louvers are situated at the upper and lower part of the partition to allow part of the cooling air to maintain personnel comfort during operation conditions.

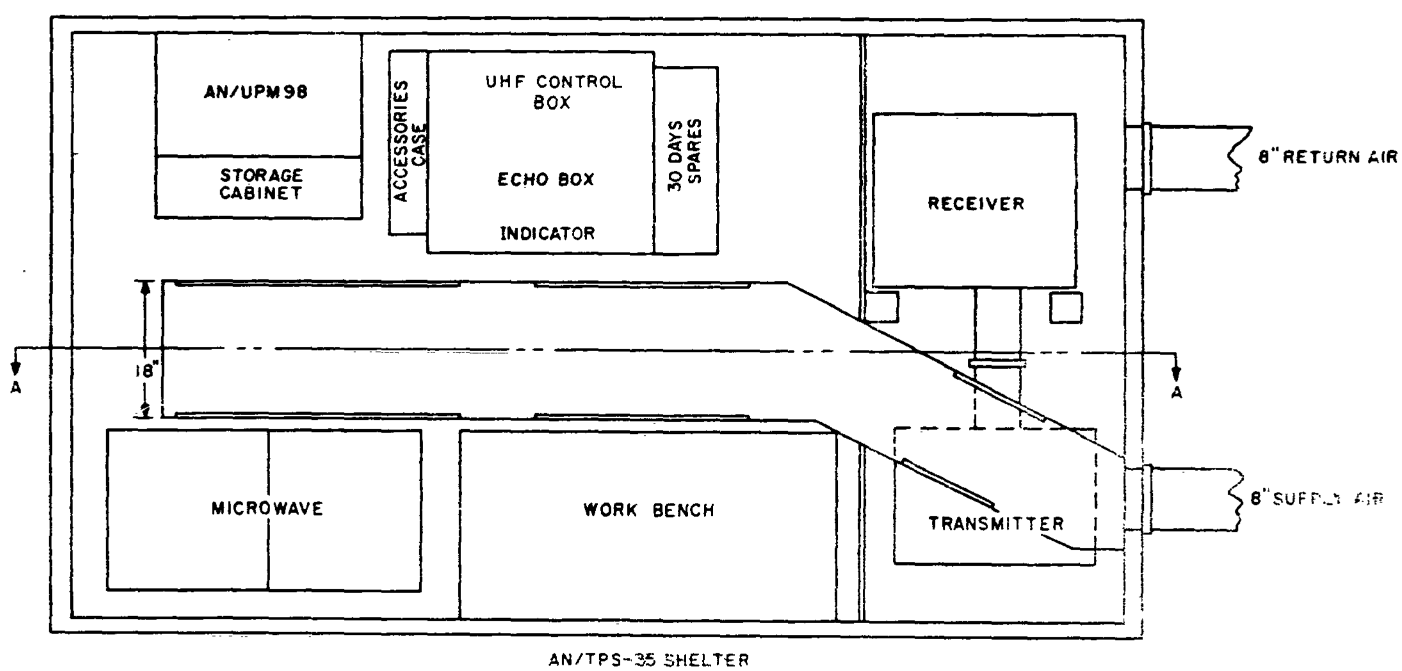


Figure 7-4. Plan View of Air Conditioning Layout

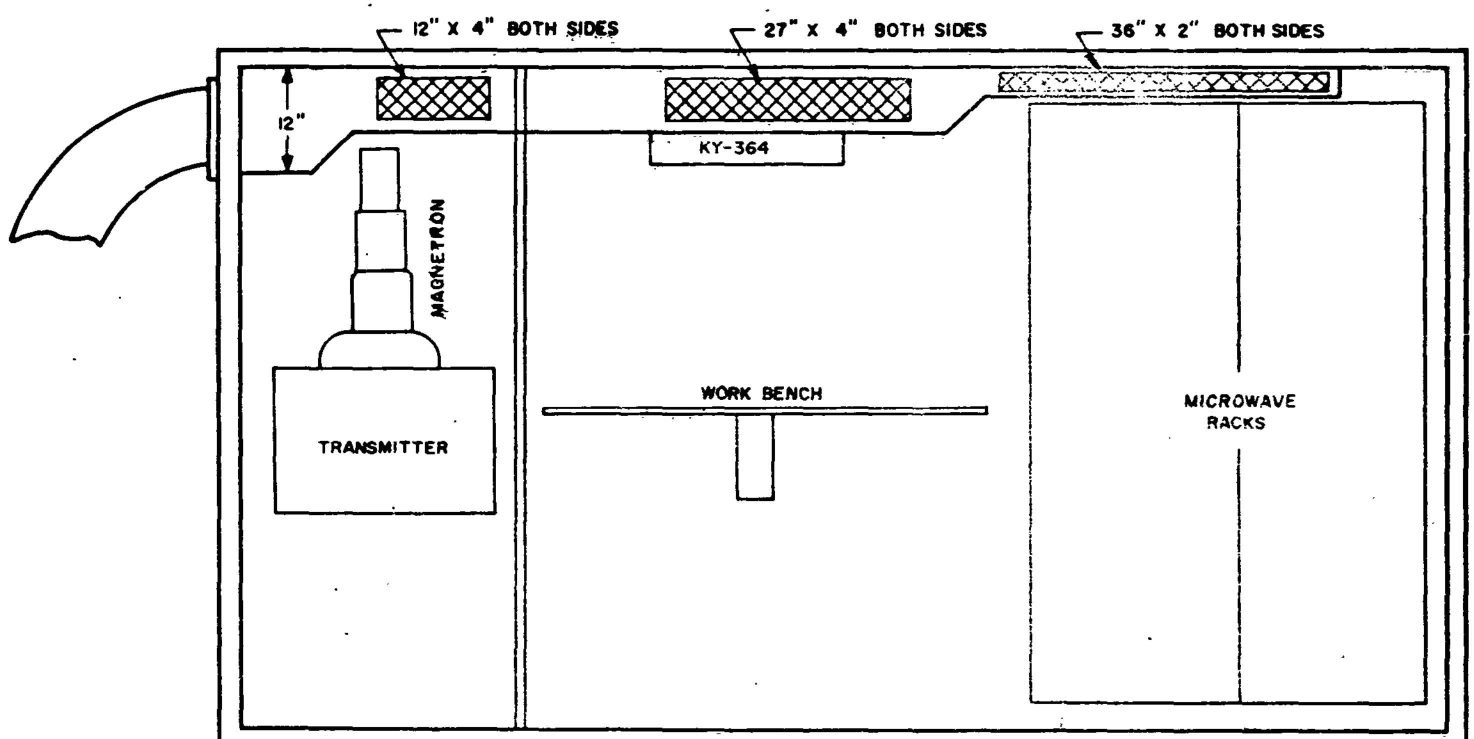


Figure 7-5. Section A-A of Air Conditioning Direct Layout

A transmitter blower and a magnetron blower are used to reduce the heat dissipating from the transmitter and the magnetron.

7.7 DESIGN REQUIRED TO CONFORM TO 463L REQUIREMENTS

The search radar van should be equipped for mechanical and operational compatibility with the 463L Cargo Handling System as installed in the C-130A airplane, and that the necessary adaptation hardware comply with the locking provisions of the MIL-P-27443 pallet and 463L guide rails. It is further required that the adaptation hardware, including the skids, shall load the aircraft structure through the rollers and guide rails, withstanding the design load factors specified in the C-130A handbooks and in Figure I of MIL-C-27691. No restraints other than that provided by the 463L guide rail system are permitted

7.8 PRIME POWER CONSUMPTION

The prime power consumption of the Search Radar Van totals 19.8 kilowatts which may be broken down as follows:

Unit	KW Rating
Radar Set	8.87
UHF Comm	0.40
RACEP	0.20
Microwave Equipment	2.03
Air Conditioning	7.50
Lights	0.30
Convenience Outlets	0.50
Total	19.80 kw

The power source should meet the following:

1) Rating: 20, 0.8 PF, 3 phase, 4 wire 120/208 volts, 400 cps. Emergency 28 volts capability for 3 amperes maximum.

2) Regulation: Voltage $\pm$ 2 1/2% no load to full load

$\pm$ 1% fixed load at fixed ambient

Frequency: $\pm$ 3% no load to full load

$\pm$ 2% fixed load to fixed ambient

Special voltages, as needed, will be derived from the prime source.

7.9 AIR CONDITIONING AND AIR FLOW CALCULATION

7.9.1 HEAT LOSS CALCULATIONS - Search Radar Van

Total Effective Area = 350 ft^2

Outside Extreme Temperature = -65°F

Assume max wind velocity at -65°F = 60 mph

U factor for van wall = .35 Btu - °F - ft^2

A. Heat Loss Through Surface of Van

Assume 65°F temperature inside van at worst conditions

$$Q = U A (t-to)$$
$$= (.35)(350)(65-(-65))$$
$$= (.35)(350)(130)$$
$$= 15,925 \text{ Btu/hr}$$

B. Heat Loss Fresh Air

25 cfm required for each man at standard conditions

Total cfm = (25) (1) = 25 cfm

Air Flow = (25) (.075) (60) = 113 lbs/hr

$$Q = W\ Cp\ (t-to)$$
$$= (113)(.24)(65-(-65))$$
$$= 3,526 \text{ Btu/hr}$$

Heat loss through Surface of Van	= 15,925
Heat loss fresh air	= 3,526
Total Heat Loss	19,451 Btu/hr

C. <u>Minimum Electric Power Dissipation in the Search Radar Van</u>

= 11, 500 Watts

$$P = 11,500 \times 3.412$$
$$= 39,238 \text{ Btu/hr}$$

D. <u>Heating Capacity of Air Conditioner</u> = 18, 400 Btu/hr

Total Heating Capacity	18, 400
	39, 238
	57, 638 Btu/hr

At worst conditions, a 57. 6K Btu/hr heating capacity exists against a load of 19, 451 to maintain a temperature of $65^{o}F$ inside the van.

7. 9. 2 HEAT GAIN CALCULATIONS

Summer wind velocities at high temperatures do not normally exceed 10 mph.

$$U \text{ van} = 0.35 \text{ Btu/hr-}^{o}\text{F -ft}^{2}$$

A. <u>Heat Gain Through Surface of Van</u>

t outside = $125^{o}F$ t inside = $80^{o}F$ (assumed)

$$Q = U A (to-ti)$$
$$= (.35)(350)(125-80)$$
$$= (.35)(350)(45)$$
$$= 5,513 \text{ Btu/hr}$$

B. <u>Heat Gain Through Solar Radiation Top and One side of Van</u>

t_s = rise above outside ambient temperature at van wall due to solar radiation.

a. For Roof:

$$t_s = \frac{aI}{f_o} = \frac{(0.7)(300)}{4.0} = 52.5^{o}F$$

where $a = 0.7$ $f_o = 4$
$I = 300$ Area (roof) = 84 ft^2

$$Q = U A t_s$$
$$= (.35)(84)(52.5)$$
$$= 1,544 \text{ Btu/hr}$$

b. For 1 Wall:

$$t_s = \frac{(0.7)\ (150)}{4} = 26.2^\circ F$$

where

$a = 0.7 \quad f_o = 4$

$I = 150 \quad \text{Area} = 84\ ft^2$

$Q = U\ A\ t_s$

$= (.35)\ (84)\ (26.2)$

$= 770$ Btu/hr

Total Heat Gain Due to Solar Radiation = 1,544
770
2,314 Btu/hr

C. Heat Load Personnel (sensible) = 100 Btu/hr

D. Fresh Air Load (sensible)

$Q = W\ 9\ (t_1 - t_2)$

$= 1000\ (0.24)\ (125-80)$

$= 1000\ (0.24)\ (45)$

$= 10,800$ Btu/hr

E. Electric Heat Load

Power Dissipation = 11,500 w

$= (11,500)\ (3.41)$

$= 39,215$ Btu/hr

F. Heat Load Personnel (Latent)

$Q = 450$ Btu/hr

G. Fresh Air Load (Latent) - None

H. Blower - Fresh Air Load

at 75 ft^3/Min fresh air

Assume temperature inside search radar back wall inclosure to be 90°F

$$Qs = (0.24)(0.66)(75)(60)(125-90)$$
$$= 24,948 \text{ Btu/hr}$$

7.9.3 HEAT GAIN SUMMARY

Heat Gain through surface of van	5,513	
Heat Gain due to solar radiation	2,314	
Heat Load personnel (sensible	100	
Fresh Air Load (sensible)	10,800	
Electric Heat Load	39,215	
Heat Loadpersonnel (latent)	450	
Fresh Air Load (latent)	0	
Total	58,392	Btu/hr

Air Conditioner Capacity = 35,000 Btu/hr
Blower Capacity 24,948

Total Cooling Capacity = 59,948 Btu/hr

The temperature of 80°F will be maintained using a 3-ton air conditioner unit.

The condition inside the van will be poorer if the relative humidity at 125°F rises above that specified as a wet bulb temperature of 75°F.

Calculations also show that a 20-foot section of 8-inch diameter ducting will produce a total water pressure drop of 0.986 inches of water and these losses are optimistic since they are based on values used for straight runs of galvanized steel ducting. A 10-inch diameter duct is suggested for exit and return to the air conditioner. The pressure drop in this 10-inch diameter duct is 0.586 inches H^2O.

7.10 SHELTER PANELS AND WIRING

7.10.1 ENTRY PANEL

An entry panel should be provided for terminating the RF feed through, antenna pedestal, IFF dipole cable, and the RF feed through for the Echo Box test equipment.

The power connections for the transmitter and magnetron blowers should be located at their respective shelter mounting flanges.

Connecting terminals should be provided on the entry panel for two telephone land lines. These terminations should conform to standard telephone practice.

There should be a connector adjacent to the microwave waveguide to service the microwave antenna heater.

The shelter should be provided with a junction box on the inside of the shelter adjacent to the door. This junction box should contain a circuit breaker for the shelter lights with dimming control, a circuit breaker for the convenience outlet circuit, a circuit breaker for the air conditioner, a circuit breaker for the radar power, a circuit breaker for the UHF communication, and a circuit breaker for the Racep unit.

The entry panel should be located on the front of the shelter and should have connectors for the following functions:

2 - convenience outlets
2 - generator input
2 - emergency 28 vdc input
1 - air conditioner power output
1 - 120/208 volts, 400 cps, 3-phase power output
1 - copper ground stud

7.10.2 UTILITY RECEPTACLES

A wiring raceway should be provided which will service four utility receptacles and form lights. These locations should be adjacent to the workbench, the microwave rack, the junction box and the console equipment. The proximity of convenience outlets to the light fixtures will conserve space and limit breakouts from the raceway.

Each receptacle should be of the dual type with covers and should be designed to operate from a 120 volt, 400 cycle sypply in the main power junction box. The controlling means should be a 10 ampere circuit breaker.

7.10.3 REMOTE OPERATION PANEL

A remoting panel should be located onthe side of the shelter between the rear curtain wall and the indicator at a height just above the floor level. This panel will provide connectors for Beacon Trigger, IFF raw video, pre-trigger, main trigger, normal video and special video. In addition, another connector should be supplied for the following functions: MTI gain (2 ea), normal receiver gain (2 ea), IFF receiver gain (2 ea), Resolver reference phase, Course reference phase, Five reference phase, Voice high, Voice low, Ground, STC gain control (2 ea), FTC in/out, PWD in/out, Circular polarization in/out, and STC in/out control.

The connections should be made for strain relief on the outside of the shelter for the RG and UG cables employed.

7.10.4 JUNCTION BOX

The junction box for interconnecting the microwave equipment cables to the radar system is located at the top, rear, of the indicator console. This should provide the connector capability for connecting signals to either remote cable or microwave. These connectors should be

appropriately marked so that only one system, either remote cable or microwave can be in operation.

7.10.5 LIGHTING

The light fixtures to be employed should provide the ambient illumination necessary for the proper operation and servicing of the Search Radar Shelter.

A "variac" type device should be provided to allow dimming of the light level. The necessary controls and switches should be located at the circuit breaker panel.

An emergency lighting system designed to operate from the 28 vdc shelter power circuit should be deployed within the shelter with the two 15-watt bulbs located inside the shelter, one on the partition wall and the other on the left inside wall near the junction box.

7.11 SET-UP TIME

The time necessary to deploy the Search Radar Shelter is approximately one hour. This time is based upon experience with installation time on a radar currently in production at RCA, components of which are proposed for the major portion of the Search Radar Shelter. In the many installations conducted with the aforementioned radar, it took eighteen minutes for six men to completely install the various equipments. In view of this experience it is feasible to predict that the set-up time for the Search Radar Shelter will be one hour for four men, including operation of the microwave equipment.

7.12 ENVIRONMENT

The Search Radar Shelter, as constructed, will be suitable for arctic or tropical deployment, and the system has air conditioning facilities which are capable of heating and cooling the shelter in ambient temperature extremes of $-65^{\circ}F$ and $+125^{\circ}F$ during operation.

7.13 CARRYING CASE FOR SEARCH ANTENNA

For transport condition, the antenna should be carried in two lightweight tubular structures.

The reflector tip sections should be stowed in a modified design of an existing type case. The approximate case size with stowed tips should be 88 by 68 by 68 inches. The existing design should be stripped of all unnecessary mechanical features, such as shock mounts, blower motors, guides for electronic boxes, and hardware not required for tip stowage. The tips should be altered to permit fork lift handling of the unit. Approximate shipping weight should be 42 pounds per tip section and 140 pounds per case for a total of 224 pounds.

The antenna senter section, antenna support, feedhorn assembly and miscellaneous hardware should be stowed in a modified design of another existing type case. The approximate case size, fully equipped, should be 88 by 60 by 56 inches with an estimated weight of 280 pounds. The existing case design should be modified to permit fork lift handling of the unit. The overall dimensions of the cases should be within the space limits established for truck of C-130A aircraft transport.

7.14 ANTENNA MAINTAINABILITY AND SERVICEABILITY

The antenna reflector surface may be dismounted into three sections: the center section and the two tip sections. The horn and feed assembly should be stud mounted to the rotating portion of the antenna pedestal, thus providing ease in dismounting. An IFF and radar rotating joint should also be provided in the pedestal for RF transmission.

7.15 MECHANICAL DISCUSSION OF SEARCH RADAR ANTENNA

The antenna reflector should be composed of three sections (center and two tips) and constructed from extruded aluminum to obtain lightweight

Tubular construction should be provided for antenna reflection support and rigidity.

7.15.1 FEED HORN

The feed horn and associated waveguide should be fabricated from rigid, L-band, aluminum waveguide. The interface waveguide should consist of a flexible section.

For conversion to circular polarization capabilities, a run of rigid 1 5/8-inch coax and filter should be utilized.

7.15.2 FEED HORN SUPPORT

The feed horn support should consist of a tubular aluminum welded frame. The four-stud interface connection should be compatible to the production pedestal.

7.15.3 COMBINED WEIGHT

The feed horn and feed horn support will weigh about 60 pounds, and increase the antenna's inertia axis by approximately 10 percent. This increase in inertia should not affect the system servo. The servo amplifiers should be sufficient to handle the increased inertia.

7.15.4 SWITCH UNIT

The switch unit, located on the feed horn, will be used to produce the circular polarization capability. The unit should consist of a series of chokes and remotely controlled retractable rods. The retraction rods should be actuated by means of a worm drive and a small electric motor.

7.16 ENVIRONMENT AND SERVICE CONDITIONS

The Search Radar Shelter in the operating condition should be capable of withstanding outside air temperature extremes of $-65^{\circ}F$ to $+125^{\circ}F$, a snow and ice load of 75 pounds per square foot, salt spray corrosion as encountered in military service, elevation of 0 to 10,000 feet, rains of tropical intensity (approximately 2 inches per hour), antenna icing up to one inch in thickness with restrictions on the radar antenna, a relative humidity variation up to 97 percent for an indefinite period, and 100 percent relative humidity with precipitation for four (4) hours.

These parameters define the suitability of the search radar system for both arctic and tropical climate conditions.

The air conditioning system provided with the Search Radar Shelter should provide operator comfort under all of the foregoing conditions and environments.

The Search Radar Shelter as designed and constructed should be capable of withstanding shock loads of 15G in the longitudinal direction and 10G lateral for 11 millisecond intervals. The shelterized system should also withstand the humping requirement of 8 miles per hour. The system should also withstand the gravel road test without damaging the interior equipment or the shelter.

SECTION 8

SITE SELECTION

Since the selection of the AN/TPS-35 site cannot be predicted at this time, the following site locations should be used only as a guide to select a site best suited to give the highest degree of performance.

8.1 IDEAL TERRAIN

The most ideal terrain to give free space patterns, which would tend to decrease the nulls in the radar pattern, would be to locate the AN/TPS-35 radar subsystem on a high point with a sharp decreasing slope in all directions. This location would tend to create a free space pattern with little or no reflections. This method is restricted to short range coverage, up to 80 miles. As the range increases, the performance will of course decrease.

8.1.1 SITE SELECTION FOR HIGH PERFORMANCE OPERATION

The other extreme, which is most suited for long range operation, is of level terrain with a good reflecting surface. The reflected energy will create a re-enforced beam pattern for long range coverage. The beam pattern therefore will depend on primary site selection with the geographic terrain one of the determining factors.

Site selection of the AN/TPS-35 subsystem, must also satisfy the proper operation of the microwave remoting system. Please refer to Section 3.10.1 for detail information concerning microwave requirements.

The two combinations must be satisfied for high performance operation.

GLOSSARY

AFC: Automatic Frequency Control

AGC: Automatic Gain Control

A4W: Augmented Four Wheels

CFAR: Constant False Alarm Rate

CSC^2: Cosecant Squared

CSL: Control Sciences Laboratory

ECCM: Electronic Counter Counter Measures

EMS: Emergency Mission Support System

FTC: Fast Time Constant

IAGC: Instantaneous Automatic Gain Control

IF: Intermediate Frequency

IFF: Identification Friend or Foe

Log/Lin/FTC: Logarithmic/Linear/Fast Time Constant

MTBF: Mean Time Between Failures

MTI: Moving Target Indicator

PAR: Precision Approach Radar

PIE: Pulse Interference Eliminator

PPI: Plan Position Indicator

PRF: Pulse Repetition Frequency

RAPCON: Radar Approach Control

SIF: Selective Identification Feature

STALO: Stable Local Oscillator

STC: Sensitivity Time Control

TACAN: Tactical Air Control and Navigation

VSI: Video Sweep Integrator